Science and Technology

SCIENCE AND RELIGION: THE INSEPARABLE ISLAMIC TRADITIONS

To the medieval Muslim and Christian, there was no separation between a religious and a **secular** world. This means there were strong links between the economy, the government, and religion. Many popes, for instance, wielded tremendous political power and controlled enormous amounts of wealth. In both of these cultures, through Renaissance times in Europe, and up to the modern era in the Muslim world, religion was woven into the fabric of everyday life instead of being a separate and distinct segment of life.

One of the first images of medieval or Renaissance Europe that comes to mind is the church. Even the humblest of villages had a church. During the Renaissance, large urban centers competed for dominance through warfare, economics and oddly enough, cathedral architecture. As cities grew in economic, political and military power, they reflected their confidence by vying to build the biggest, most stunning cathedrals of Europe. Places of worship, whether cathedral or *masjid* (mosque), were the cultural and economic centers of their communities. In Europe, until the latter half of the 16th century, when buildings devoted solely to the theater appeared, the church or cathedral had been the only gathering place for indoor public activities. It was once considered normal to use churches for festival banquets, political discourse, buying and selling trade goods, even for storage of ammunition during times of war.

In European society and Muslim society, faith has been woven into the fabric of life from birth to death. This phenomenon can be seen in such deceptively simple things as the use of religious expressions in everyday conversation. Saying "Bless you" when someone sneezes, or saying "Good-bye" (literally, "God be with you") or using the English expression, "God willing" or "Thank God" are signs that people acknowledge God's presence in their lives. Reading literature from medieval, Renaissance and later authors in Western culture provides ample evidence of this deeply-entrenched worldview. Similarly, the everyday life of a Muslim is infused with phrases that reflect the influence of religion on many of the common expressions used in their language. Tell a group of Muslims you'll see them tomorrow, and they will probably reply *In sha' Allah* ("if God wills"). The *Qur'an* actually commands believers to say this whenever they intend to do something. In this way, they remind one another of their dependence upon God's will in every act. Devout Muslims begin every act, from starting a journey to taking an exam at school, with *Bismillah*, an expression which says "In the name of God, the Compassionate and the Merciful," stating first that it is only by the mercy of God that they can proceed. There are many other such expressions, and their use is very widespread among Muslims everywhere.

Muslim culture and scholarship is characterized by a connection between faith and every other aspect of existence. Even the term "religion" is not a completely adequate way to describe Islam, which believers call *al-Din al-Islam* (total way of life centered on submission to God). In an Islamic view, there is no area of life, no field of activity that is not affected by the laws and ongoing influence of the Creator. Muslims maintain that

there can be no contradiction between any aspect of Islam as revealed in the *Qur'an*, and any aspect of God's creation. This worldview has had a very significant impact on Muslim scholarship and the sciences:

- Science was seen as an affirmation of the majesty and divine mercy of God's creation.
- The study of the creation is viewed as a blessed pursuit, as a way of glorifying God and increasing faith, by coming to understand His creation, and hence the Divine Will.
- The *Qur'an* itself invites believers to study and reason and discover the workings of creation, as proof of God's existence, and to develop useful things for humankind's benefit.

As Islam rapidly spread out of the Arabian peninsula, Muslim rulers came into contact with a wealth of scholarly materials from such ancient centers of learning as Greece, Persia, India and Egypt. Because of the link between religion and science, the greater the Muslim civilization became, the more dedication its leaders showed to supporting scholarship under court patronage. Philosophers, geographers, artists, botanists, translators, physicians were all given a hearty welcome and generous support to remain at the court of the most powerful Muslim rulers. At Muslim centers of power and urban culture in the Middle East, Asia, Africa and Spain, translation centers attracted those fluent in Arabic, Syriac, Pahlavi (Persian), Latin and Sanskrit. These individuals participated in the great intermingling and development of ancient scientific learning. These adventuresome scholars planted seeds that blossomed into many scientific and technological achievements of Muslim civilization. After a number of centuries, the knowledge in these fields was transferred to Europe and eventually helped stimulate the European Renaissance and the scientific achievements that accompanied it, and the scientific revolution that followed it.

Links Between Muslim Scientific Study and Religious Faith

One of the many *hadiths* (sayings of the Prophet Muhammad) that encourages scholarship and scientific study says:

> "*Verily the men of knowledge are the heirs of the prophets.*"

Islam is a **monotheistic** (belief in One God) belief and value system whose fundamental message is *tawhid*, or affirmation of the Oneness of God. All aspects of the created universe are seen as integral parts of a unified cosmic system; *a unity of many parts*. This basic belief is reflected in Muslim art, architecture, philosophy and science. Hence, Muslim scholarship was rarely confronted by theological disputes to the extent that was seen in the Christian world. In addition, since there is no central religious authority or ordained clergy in Islam, scientific discovery did not confront institutional opposition. To the contrary, scientific inquiry was generously supported in various ways by Muslim cultural institutions, based on Islamic teachings and values:

- Scholarship and the sacrifices it entailed were held in the highest esteem.
- Rulers generously patronized preservation and development of learning from an early date.
- Travel, commerce and the spread of Arabic as a universal language promoted contact among peoples and the circulation of new ideas, products and knowledge.
- The disciplines and requirements of Islamic worship and practice challenged Muslim societies to fulfill these duties according to exacting scientific standards.
- Tolerance across religious and cultural lines promoted absorption of learning from many traditions. This enabled non-Muslims to excel in scholarly study under the patronage of Muslim rulers. Many brilliant discoveries were made by Christians, Jews, Zoroastrians, Hindus and scholars of other faiths living under Muslim rule.

As late as 1633, Galileo was imprisoned in Europe as a heretic for disputing the church on several issues. One of his most dangerous acts was to claim that the planets rotate around the sun, an idea that the Greek Aristarchus had postulated in the 3rd century BCE. Church officials of the day saw this as blasphemy because it contradicted their understanding of Christian scripture. They believed that *man* was the focal point of God's creation. Because of this belief, they also felt that the earth (on which the Garden of Eden and Adam were placed) was the center of the cosmic universe. When Galileo claimed that the sun was at the center of the universe he seriously challenged the teachings of the Church.

Although debates over faith and reason, philosophy vs. religion and other speculative topics did cause controversy during Muslim history, scholars working in the field of scientific observation and experimentation were protected from predicaments like Galileo's. Science developed on a different basis in Muslim culture, and religious practice was often enhanced by the development of science. For example, knowledge of astronomy and its sister science, mathematics, were needed for the purpose of keeping accurate time and developing calendars for religious observances and daily prayers. Mathematics and geography joined together to help determine the direction of prayer from any location, and to ensure travelers access to the *Hajj*, or pilgrimage routes. Medical sciences and a good understanding of hygiene and sanitation are very important for maintaining the personal habits of regular washing and bathing *required* of every Muslim. This link between science and Islamic religious practices also led to a disciplined, rationalistic and systematic attitude toward the preservation and development of knowledge in the "religious" disciplines, like *Qur'anic* studies, history and jurisprudence, that carried over into other areas.

As a result, Islamic science has always been interwoven with the sacred. Scholars working under Muslim patronage developed their own philosophy, astronomy, mathematics, and medicine while integrating them into the Muslim worldview, based on *tawhid* (the Oneness of God) and *Qur'anic* revelation. Scientists drew inspiration in particular from sacred passages which pointed to the wonders and ordering of the natural world as signs of God's mercy. The *Qur'an* speaks of such things as rain, food, wind and gardens as signs that humankind has received many blessings from God.

> *"Among His Signs is this: that He sends the winds as heralds of glad tidings, giving you a taste of His Grace and Mercy." (30:46)*

> *"It is He Who makes the stars as beacons for you, that you may guide yourselves with their help, through the dark spaces of land and sea." (6:97)*

> *"It is He Who sends down rain from the skies; with it We produce vegetation of all kinds…We produce grain, heaped up at harvest…and gardens of grapes and olives." (6:99)*

> *"By the sun and its glorious splendor; By the moon as it follows (the sun); By the day as it shows up the sun's glory; By the night as it conceals it…By the earth and its wide expanse; Truly he succeeds that purifies it, and he fails that corrupts it." (91:1-10)*

The whole pageant of creation is described in the revelations of the *Qur'an*. With this inspiration in their hearts, Muslim scholars in cities from Spain to Asia worked alongside people of many faiths and enthusiastically set the foundations upon which European scientific scholarship and technology would later build.

CONTRIBUTIONS OF MUSLIMS TO THE FIELD OF MATHEMATICS

Muslim scientists agreed with the ancient Greeks that mathematics formed the foundation for all scientific study. If one could build a basic understanding of mathematics, then any other area of scholarship could be approached by using the skills of logic and reasoning developed through the study of mathematics. In fact, Aristotle, whom Arabs called "The Foremost Teacher" had inscribed above the door of his house:

> *"Let no one enter who does not have a knowledge of mathematics."*

As early as the 8th century, scholars traveled to the *Bayt al-Hikmah* (House of Wisdom) in Baghdad where they worked toward a fusion of Greek, Persian and Indian sciences with the faith of Islam. Those working in Baghdad soon perceived the science of mathematics as the gateway to understanding not only the physical world around them, but the Unity of the spiritual world as well. They clearly perceived the concept of *tawhid*, or the Unity of the One God, manifested in mathematics. Mathematics became a way of expressing the idea of God's Unity in multiplicity. For example, there is geometric perfection in the honeycomb of a beehive, which is constructed from a series of eight-sided units, yet one unit could not function without the others. (Did you ever see a one-unit honeycomb?) Philosophers and scientists contemplated nature and found deep religious symbolism in such things. For instance, in the minds of early Muslim scholars, a honeycomb was a symbol, or a sign, of the workings of the Creator. Like each unit of a honeycomb which needs the other units *and* the bees to exist, man cannot survive without the help of his fellow humans and the guidance and mercy of Allah. This link between numbers and the Divine was so critical to early Muslim scholars that the science of numbers was considered "the tongue which speaks of Unity and transcendence.[1]

The main elements of mathematical studies were arithmetic, geometry, astronomy and music. Many Muslim scholars, like al-Farabi, wrote essays on the links between music and mathematics, as well as music's soothing effect on the soul. These books were translated into Latin and studied by later European philosophers. Music was actually a branch of mathematical studies. Muslim scholars had their strongest influence on Western mathematics in the field of algebra and trigonometry. The word "algebra" itself is a Latinized Arabic term, the first part of *al-jabr wal muqabala*—restoration and completion of the parts. The same word is used to describe setting broken bones.

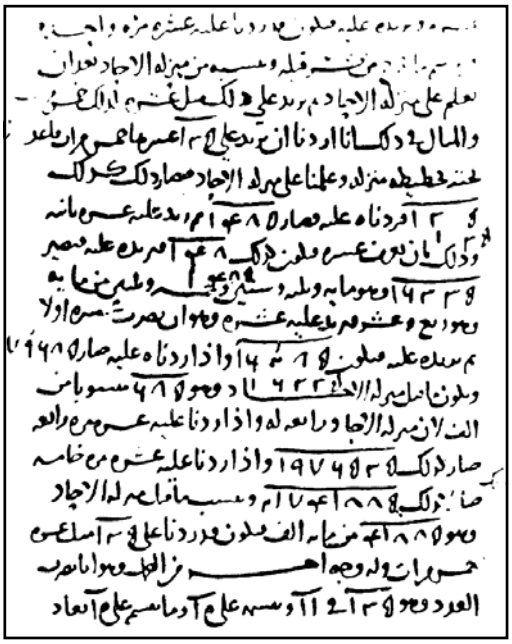
Muslims blended the influence of two ancient cultures to develop an Islamic philosophy of mathematics. One was that of the Greeks, who used mathematics to express the finite order of the cosmos through the understanding of numbers and figures. The works of Euclid and Nicomachus of Gerasa were important in building this foundation. As early as the 8th century, their works were translated at the *Bayt al-Hikmah*. Work on number theory continued for the next several centuries, and included the names of many important Muslim mathematicians like Thabit Ibn Qurrah, Kamal al-Din al-Farisi, al-Khwarizmi, and Umar Khayyam. Khayyam is best known in the West as a poet, but he also produced important works in non-Euclidean geometry and irrational numbers. With their inquisitive and critical attitude, Muslim mathematicians were able to revise several of Aristotle's ideas in mathematics and make significant advances upon which Western mathematicians later drew. The other influence came from India, where scholars saw mathematics through eastern wisdom, based on the Infinite. Indian mathematicians had devised a system of writing numbers that revolutionized the study of mathematics. Using the revolutionary new tool of Hindi numerals, and the notion of zero as a placeholder, scholars in the Muslim tradition developed mathematical theorems and proofs based upon these earlier sources and answered many of the questions which ancient scholars had set forth, but had been unable to answer.

1. Seyyed Hossein Nasr, ***Science and Civilization in Islam***, (Cambridge, MA: Harvard University Press, 1968), p.147.

ZOOMING IN ON HISTORY

ARABIC NUMERALS, ZERO AND DECIMALS

In the 9th century, mathematicians working in India came up with the ideas of using symbols to represent a quantity, of numerical places, and of zero as a space holder.



Page of the first Arabic manuscript showing use of decimals, which entered Europe several centuries later.

- Indian scholars began to use a symbol, such as "3" or "7" to represent a specific number, or quantity. This was a radical idea which enabled new calculations to be performed as never before. To understand the importance of these numerical symbols we use today and refer to as "Arabic Numerals", try to perform a simple numerical calculation, such as adding 32, 24 and 75 and dividing that by 12, using Roman Numerals. It can't be done!
- Another important mathematical concept which entered Muslim culture from India is the idea of "place values". When we write a number, we put digits into rows or places which are identified as the "thousands place", the "hundreds place" the "tens place" and so on, so that the series of digits 4-3-7-5 means four thousand, three hundred and seventy five. By writing numbers this way, the scholars were able to perform basic tasks such as adding and subtracting with great ease. Before that, computations were done using hands and fingers or with the abacus, a Chinese invention.
- Until the introduction of the number Zero, there was no way to express the concept of "nothing" in mathematics. This may not seem important, until you try to write a number like four hundred and six, without using a zero. Again, it can't be done. There's a big difference between 406 and 46! Symbols had been used to indicate the absence of a number as early as the Mayan Classic Period in the Americas (250-900 CE), but it wasn't until the 9th century that scholars made successful mathematical use of the symbol.

These ideas revolutionized mathematics, and gave Muslim scholars many of the tools they needed to develop other fields of mathematics such as algebra, plane and solid geometry, trigonometry and calculus.

Trigonometry was another area in which Muslim mathematicians made major contributions. Using triangulation to measure the movement of stars, to determine position on the earth using reference points, and to measure distances accurately for cartography and engineering were important skills aided by mathematical knowledge. Muslim mathematicians prepared trigonometric tables and introduced to the West the concepts of sine, cosine, tangent and many other terms. Inheriting and passing on the Babylonian system of base sixty fractions, Muslim mathematicians applied the "arithmetic of the astronomers" or the "arithmetic of degrees and minutes" to mathematical geography, which we know today as longitude and latitude. Al-Faraghani led an expedition to test the Greeks' calculation of the earth's circumference by measuring a degree of longitude. Al-Faraghani's measurement, cited by Columbus in his diary (using an incorrect understanding of the unit, it turns out), was very close to modern measurements of the earth.

The links between mathematics and astronomy came to maturity as Muslim scholars developed the science of spherical trigonometry to understand the motion of heavenly bodies. In astronomy, the help of Sabaean scholars was critical. Sabaeans, or "star worshippers", had originally been desert dwellers in the region of Iraq.

They had a deep understanding of astronomical phenomenon which developed beyond that of many other cultural groups in the region. Inheriting this knowledge, three famous Muslim engineers and mathematicians, the sons of Musa bin Shakir, wrote an important work on *The Measurement of Plane and Spherical Figures.* Later, this was translated by a European scholar, Gerard of Cremona, and eventually printed in Latin. Ibn Haytham, known in the West for his optical achievements as "Alhazen", was also a mathematician who dealt with the problem of curved surfaces, particularly lenses. Through careful calculation and experiment, he solved mathematical problems dealing with the behavior of light, its reflection and refraction. This work contributed greatly to the making of glasses, telescopes, and later, microscopes. Using geometry, Ibn Haytham essentially solved fourth degree equations in his famous solution to what is called "Alhazen's problem."

Muhammad ibn Musa al-Khwarizmi is perhaps the most famous of all Muslim mathematicians. His "Book of al-Khwarizmi" became the source of our word "algorithm". Working in the 9th century, this scholar wrote works which were later translated into Latin, bringing *al-jabr* (algebra) to European scholars. Following is a sampling of al-Khwarizmi's writing, as translated in 1183 by Robert of Chester:

The Book of Al-Gebra and Al-Muqabola Containing Demonstrations of the Rules of the Equations of Algebra

Written in Arabic during the 9th century by al-Khwarizmi and translated into Latin about 1183 CE, by Robert of Chester, in the city of Segovia

In the name of God, tender and compassionate, begins *The Book of Restoration and Opposition* of numbers put forth by Muhammad al-Khwarizmi, the son of Musa. (The Prophet) Muhammad said "Praise God the Creator who has bestowed upon man the power to discover the significance of numbers." Indeed, reflecting that all things which men need require computation, I discovered that all things involve the number and I discovered that the number is nothing other than that which is composed of units. Unity therefore is implied in every number. Moreover, I discovered all numbers to be so arranged that they proceed from unity up to ten. The number ten is treated in the same manner as the unit, and for this reason, doubled and tripled just as in the case of unity.

Out of its duplication arises twenty, and from its triplication, thirty. And so multiplying the number ten, you arrive at one hundred. Again, the number 100 is doubled and tripled like the number ten. So by doubling and tripling, etc., the number one hundred grows to one thousand. In this way, multiplying the number one thousand according to the various denominations of numbers, you come even to the investigation of numbers to infinity.

Furthermore I discovered that the numbers of restoration and opposition are composed of these three kinds: namely, roots, squares and numbers. However, the number alone is connected neither with roots, nor with squares by any ratio. Of these then, the root is anything composed of units which can be multiplied by itself, or that which is found to be diminished below unity when multiplied by itself. The square is that which results from the multiplication of a root by itself.

Of these three forms, then, two may be equal to each other, as for example:

Squares equal to roots

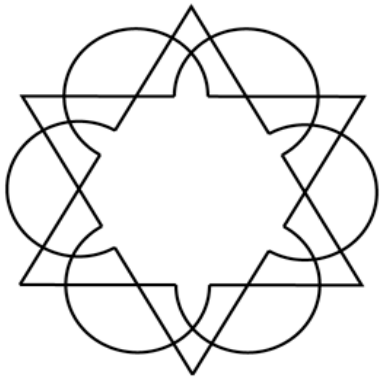
Squares equal to numbers, and

Roots equal to numbers[2]

2. Nasr, p. 158.

The influence of Arab mathematicians on the West began to be felt after 1085 CE, when the Muslim city of Toledo, with its tremendous libraries and university, was conquered by Spanish Christians. European scholars delved into the books they discovered and passed on what they read. While it took numerous introductions and several centuries to achieve widespread use of Arabic numerals, Leonard of Pisa (Fibonacci) is widely credited with ensuring their adoption. Fibonacci wrote his *Liber Abacci* in 1202, in which he introduced the use of place values, algebra and Arabic numerals to the West. Ninth-century texts on geometry written by the three Banu Musa brothers of Baghdad were passed to the Latin world in the 12th century by Gerard of Cremona. Numerous Arabic translations of Euclid and other Greek mathematical works were translated into Latin, often together with the comments and revisions of Muslim mathematicians.

Additionally, answers to some mathematical problems posed by the ancients had been passed down through the centuries and simply accepted as correct. The Arab mathematicians however, developed the art of searching for the proof before mathematical equations would be accepted without question. They opened some critiques of ancient ideas and discovered some mathematical puzzles that Muslim scientists then queried for as long as 500 years! While they were not solved, their proofs paved the way for communication on mathematical ideas with their European successors centuries later. For example, a problem of parallels that Muslim mathematicians pursued for generations was translated in the 12th century, but was not picked up until the 17th century by European mathematicians. When the Europeans began to examine these puzzling questions, there was a wealth of accumulated commentary on these problems that they could turn to for guidance. The result was a breakthrough in mathematics. Some of these ancient puzzles are still on the table, and others lie waiting for ever more sophisticated solutions. In any case, the contributions of Muslim mathematicians take their places among the universally recognized milestones of science.



CONTRIBUTIONS OF MUSLIMS TO THE FIELD OF CHEMISTRY

A Side Note to Science: The Tradition of Alchemy

Alchemy is considered at once a science and an art. It is concerned with the transformation and change of natural substances, or matter, both in the physical and the spiritual sense. Alchemists attempted to create a compound called *Elixer,* or Philosopher's Stone, which they believed would enable them to change base metals such as silver, mercury, tin or lead, into gold. Through the process of learning, which was considered an *art*, it was believed that base metals (which correspond to humanity's animal desires and ignorance) could be transformed into gold (which corresponds to wisdom and faith in God).

Alchemists hoped that they could bring about a transmutation, both in the physical realm **and** in the spiritual world of man, thus creating pure perfection. For this reason, their efforts were focused in two main areas; the mineral world and the soul. Their work was also interwoven into the field of medicine, for alchemists believed that they should use all the resources that God had created, mineral as well as vegetable (herbal remedies) to assist man in his physical and spiritual well being.

The roots of alchemy can be traced to ancient cultures ranging from China to Egypt, with evidence of its practice appearing in many regions of the hemisphere. The Chinese combined alchemy with the philosophy of Taoism and claimed to have the ability to change base metals into gold with the help of a "medicine," or substance they had discovered. This gold was then believed to have the power to cure all illnesses and prolong life. In Egypt, the methods for transmuting metals were one of the secrets kept by the temple priests. Their methods had become known, however, by the 2nd century at the Academy of Alexandria. There the study of alchemy melded together art, mathematics, Eastern mysticism and Aristotle's philosophy concerning the composition of matter. Aristotle felt that all things were made of differing amounts of four basic elements: water, earth, fire and air. He therefore theorized that base metals could be turned into gold by altering the amount of certain elements within them.

Nestorian Christians were instrumental in transmitting this field of study to the Latin West. In the 5th century they were being persecuted by the official Orthodox Church in the Byzantine Empire (based in present day Turkey) due to differences in religious beliefs. These scientists fled to the Near East where they were able to continue their work. They translated many Greek alchemical manuscripts into Syriac, the language of the Nestorian Christians. These documents were then taken to Baghdad where they were translated into Arabic in the 8th century at the *Bayt al-Hikmah* (House of Wisdom). By the 12th century, a few Latin translations were appearing in European libraries.

Development of the Science of Chemistry by Muslim Alchemists

This long tradition of alchemy reflected man's need to combine the physical realm with the spiritual. This tradition fell on fertile soil in Muslim lands. In their quest for the pure Philosopher's Stone, alchemists conducted and recorded experiments which became invaluable building blocks of later chemical experimentation. While alchemy was essentially a "false science," its long pursuit turned out to be valuable. Francis Bacon (1561-1626), an early pioneer of European science, recognized the importance of the false science of alchemy with the story of a dying man and his sons:

> *"…the man who told his sons that he had left them gold buried somewhere in his vineyard; where they by digging found no gold, but by turning the mould [soil] about the roots of the vines, procured [got] a plentiful harvest.[3]"*

The basis of alchemy was the belief that "everything is in everything"; it is a process meant to improve that which already exists—if base metals can be transformed into gold, then the crudest of all people could be lead to the Divine. Those who saw alchemy in a more spiritual light felt that in order to bring a state of purity to that which already exists, one first had to bring about the end, or the "death" of the existing material. In the case of metals; they needed to be melted down to their lowest state. In the case of man: he needed to destroy his ego and worldly desires in order to make possible the process of regeneration and growth toward spiritual awakening. When a person reached this point, the alchemist could start with a "clean slate," guiding the seeker on his or her quest for the path to purity and understanding of the sacred.

The writings of al-Razi (865-925 CE), Rhazes in the West, gave elaborate descriptions of the process of smelting metals, for example. While lacking any reference to the symbolic or spiritual aspect of alchemy, his book *On the Secret of Secrets* offers us a look into the world of the early discovery of chemical processes:

> *"The hardest of the "Bodies" to melt is Iron. It does not become as fluid as water, except after treatment and the use of Medicines. The process of melting is this. Take filings of iron, as much as you want, and having thrown on them one-quarter their weight of powdered red (arsenic sulfide). Stir the mixture up, then put it in a bag, and after luting it with good clay, place it in a hot oven. Take it out and weigh it. Then throw upon it one-sixth of its weight of (hydrated sodium carbonate), and add olive oil to the mixture. Next it is placed in a perforated crucible (oven), fitted on to another. What comes down is received, and (again) melted. Then sal-ammoniac and Syrian vitriol—both powdered and mixed with olive oil—are taken and made into small balls, and it (the fused product) is fed with these. It may be melted as many times as you choose, for that adds to its feasibility and whiteness. If this (process) is repeated, the mass becomes so soft that it may be beaten out, and it will be as easily melted as silver.[4]"*

In further works, alchemists such as Jabir ibn Hayyan (who was known in his Latin translations as Geber) described the properties and use of such substances as alcohol (an Arabic word), alum, sulfur, lime, glass, and many other materials which are used in scientific experimentation. Geber's *Summa Perfectionis* and *Chest of Wisdom* were handbooks of chemical knowledge combed through by European scientists. These books described processes by which minerals transform with heat, through reacting with other substances, and by exposure to air. Scientists learned to control chemical changes such as calcination and crystallization. They

3. Quoted in Frances and Joseph Gies, ***Cathedral, Forge and Waterwheel***, (New York: HarperCollins, 1994), p. 162.

4. Seyyed Hossein Nasr, ***Science and Civilization in Islam***, (Cambridge, MA: Harvard University Press, 1968), p. 270.

developed and described many substances that have useful chemical applications, either in pharmacy or manufacturing processes. They identified the chemical properties of materials such as ceramics, glass and metals. They developed laboratory utensils for pulverizing, melting, filtering, distilling and burning substances at various temperatures. Some of these tools still have their Arabic names, like the *alembic*, and some of the beakers and glass containers have maintained their original shapes and functions.

Alchemists even created a gas burner for gentle heating of substances. This was developed in Iraq, where gas sources are plentiful close to the earth's surface. Experiments were also done with distillation of petroleum, producing white solvents and using them, for example, to make waterproof varnishes for wood.[5] Certainly, not every Muslim observer of natural materials, metals and substances was an alchemist. Al-Biruni (died after 1050 CE) had a voracious appetite for knowledge, and recorded reams of information during his extensive travels and observations. Al-Biruni described mining, metalworking and many other processes practiced by artisans and others in various places. Al-Kindi, the multi-talented scientist and philosopher counted a book on *Perfume Chemistry and Distillation* among his many works.

Many of the processes fathered by alchemy and observation by Muslim scientists bore fruit in areas as diverse as cosmetics (essences of flowers and other organic perfumes), pharmacy (disinfectants, ointments and syrups including essences of herbs and minerals), ceramics and glass (mineral salts for glazes, clay and heat processes), arts and crafts (pigments for woodworking, textiles, glazes, paints and inks), and of course metalworking and mining, in which new ways of extracting metals and derivatives of metals from ores, as well as useful properties of metallic substances were discovered. What the best workers in this tradition achieved was to make a record and pursue ideas about the behavior, alteration and transformation of natural substances, and to develop tools and instruments for doing so. These processes are the ones that scientists of many cultures have used to work the "miracles" of chemistry that have done so much to change and enhance our ways of life to the present.

Alchemy in Europe

Alchemy's ideas of death and rebirth were popular particularly with Sufis (Muslims on the mystic path) and Kabbalists (followers of the mystical branch of Judaism). These concepts found a particularly fertile ground among Christians due to their doctrinal belief in the death and resurrection of Christ. The Bible states "unless a man be born again, he cannot see the kingdom of God." Passages such as this became inspiration to a group of devout Christian alchemists who are perhaps best represented by Nicolas Flamel, a scribe and bookseller who was born near Paris in 1330. Flamel's writing reflected the symbolic tradition in alchemy, with a focus on animal symbolism. The wingless dragon, for example, symbolized fixed sulfur whereas the winged dragon symbolized active mercury. Flamel was most successful in placing a universal, cosmic symbolism which had woven its way through Islam, Hindu Tantrism, and Taoism, into a Christian worldview. In an essay entitled *Of the Theological Interpretations, which may be given to these Hieroglyphics, according to the sense of the Author*, he wrote:

> *"I have made to be drawn with a coal, and grossly-painted, a man all black who looks straight upon these Hieroglyphics, about whom there is written in French 'I see a marvel whereat I am much amazed'. This, as also three plates of Iron and Copper gilt, on the East, West, and South of the Arch, where these Hieroglyphics are, in the midst of the Churchyard, representing the holy Passion and Resurrection of the Son of God; this ought not to be otherwise interpreted, than according to the common Theological sense, saving that the black man, may as well proclaim it a wonder to see the admirable works of God in the transmutation of Metals, which is figured in the Hieroglyphics which he so attentively looks upon, as to see buried so many bodies, which shall rise again out of their Tombs at the fearful day of Judgment.[6]"*

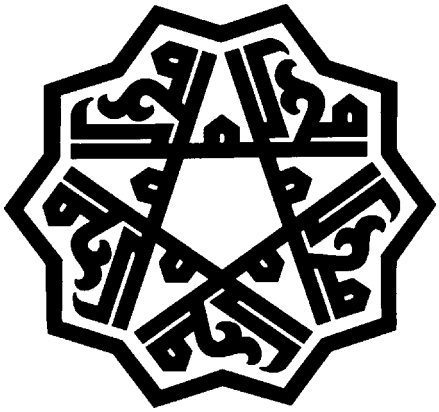
5. Ahmad Y. al-Hassan, Donald Hill, *Islamic Technology: An Illustrated History*, (Cambridge: Cambridge University Press/UNESCO, 1986), p. 144.

6. Nasr, p. 287.

Many Arabic alchemical texts were translated into Latin in the 12th century and then developed further by Latin Christendom's believers in the death and resurrection of Christ. The influence of these texts was seen in Renaissance Europe as well, where we see many famous alchemists such as Thomas Norton, Basil Valentine, and Count Bernard of Treviso. Isaac Newton, in his scientific writings, referred extensively to alchemy. Roger Bacon (1214-1294) and Albertus Magnus (1193-1280), when writing their treatises on the nature of matter, included alchemical explanations in their scientific theories. Bacon also used an alchemical recipe for creating gunpowder.

European kings and nobles came to employ alchemists at their courts in an effort to increase their holdings of gold and to prolong their lives. While some of these alchemists were conducting experiments which led to modern Chemistry, many of them lost their heads when they failed to produce the mountains of gold their employers were expecting. In fact, King Frederick of Wurzburg even maintained a special gallows just for hanging alchemists.

For obvious reasons, alchemists soon turned more of their attention toward preparing medicines for their patrons. They made advances which forwarded the fields of mathematics, pharmacology, astronomy and chemistry. These individuals were instrumental in developing the building blocks of today's scientific method; that is, the idea that **scientific research should be done through closely controlled experimentation, observation and written records**. Francis Bacon (1561-1626), who quoted the story about the vineyard, is often credited in the West with developing the scientific method, yet he was an avid student of Muslim scientific works during the 1500s, when these works were first printed and became widely available to Europe's thinkers. Today, chemists work in laboratories which are filled with scientific instruments developed by their predecessors. These instruments still serve as some of the basic tools of the modern science lab. Alchemists developed methods of scientific observation, discovered new chemicals and processes such as smelting of metals and distillation. The chemical facts that had been discovered during their quest for the Philosopher's Stone set the basis for the modern Chemistry we study today.



CONTRIBUTIONS OF MUSLIMS TO THE FIELD OF ASTRONOMY

Muslims made scientific advances in many fields, but they seemed to truly excel in the areas of medicine, mathematics and astronomy. Links are strong between science, sacred scripture and the Islamic quest for understanding the Divine Reality as manifested in this physical world. Therefore, religious beliefs and practices provide a strong incentive particularly for the study and interpretation of mathematics and astronomy.

The historical foundation for the Islamic interest in astronomy is probably related to the fact that Islam originally came to humankind within a desert setting. The Arabian peninsula and much of the Middle East was populated by tribal nomads who had traversed the forbidding desert from pre-Biblical times. As early as 3500 BCE many of these nomadic peoples had settled into agricultural communities which eventually were to develop into some of the earliest urban centers known. Cities such as Sumer, Ur and Persepolis developed near the Tigris and Euphrates rivers while at the same time, ancient civilizations in many other parts of the world were creating sophisticated urban cultures along their own great river valleys.

A 16th-century Venetian woodcut showing Muslim astronomers at work.

Invaders and migrants repeatedly crossed the Fertile Crescent as Hebrews, Persians, Arabs and other groups traveled along the ancient trade and migration routes of the region. Living in such rugged terrain, tribal nomads became a strong, self-sufficient stock of people who literally faced life and death situations on a daily basis. It is easy to get lost in desert terrain, and once lost, the chances of survival are slim. For this reason, early nomadic tribes developed a deep understanding of what was to become their most crucial of desert guides—the stars. The Arabian Peninsula also occupies a position on major trade routes by land and sea. Besides being the world's largest peninsula, it is also the only one, suspended between Asia and Africa, that is surrounded on *four* sides by water. Their location on ancient trade routes, in combination with knowledge of navigation by the stars, led the coastal Arabs into ocean-going trade. At sea, their knowledge was enhanced by the changing views of the heavens as their ships crossed the equator into the southern seas.

As early as the 3rd century CE, many urban cultures had developed observatories where scholars shared their understanding of the heavenly bodies. A great meeting of intellectual legacies took place, mingling the wisdom of the Greeks, Africans, Babylonians, Persians, Indians and Chinese. Christian centers of scholarship translated ancient Greek manuscripts into Syriac and then passed their learning on to the Arabs in later centuries.

Another group, sometimes called "Sabaean Star Gazers" combined Greek tradition with elements of ancient Babylonian learning in mathematics and astronomy. This religious community traced its origin to the Prophet Idris (or Enoch in the Old Testament). Muslim scientists came to revere Idris as the founder of the "science of the stars", and to respect the Sabaeans for their tremendously advanced understanding of astronomy. Adding to the knowledge of the Sabaeans were the Persian and Indian scholars who gathered at Jundi-Shapur (in Iran), making important contributions to the study of astronomy.

After the 7th-century advent of Islam the study of astronomy intensified for reasons that reflect Islamic beliefs and religious practices. Many passages of the *Qur'an* mention the heavenly bodies as some of the primary signs of God's mercy and guidance. These passages speak poetically of the wonders of God's creations and encourage people to contemplate the movements of the sun, moon and stars as symbols of the miraculous workings of the universe. The heavenly bodies became more than simple specks of light in the sky. They became literally guiding lights, representing the harmony between God's mercy and humanity's state of helplessness without that mercy.

> *"By the sun, and his (glorious) splendour; By the moon as she follows him*
> *By the day as it shows up the sun's glory; By the night as it conceals it;*
> *By the firmament and its (wonderful) structure*
> *Truly he succeeds that purifies it, and he fails that corrupts it!" (91:1-10)*

> *"He has made subject to you the night and the day; the sun and the moon;*
> *and the stars are in subjection by His command: verily in this are signs for men who are wise." (16:12)*

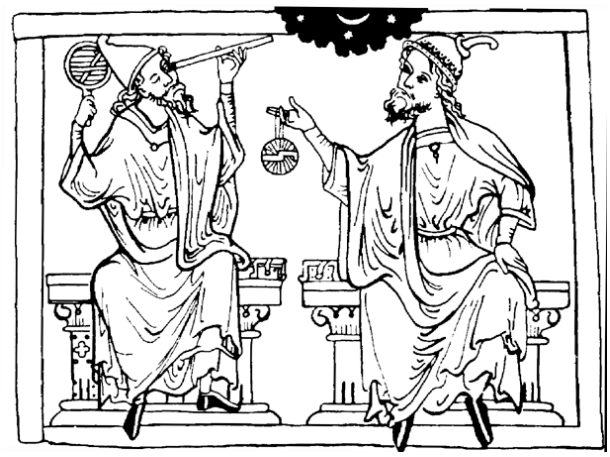
> *"He it is who has made the sun a source of radiant light and the moon a light reflected,*
> *and has determined for it phases so that you might know how to compute the years*
> *and to measure time. None of this has God created without an inner truth." (10:5)*

> *"He has created the heavens and the earth with truth. He makes night to succeed day,*
> *and He makes day to succeed night, and He constrains the sun and the moon to give service, each running on for an appointed term. Is not He the Mighty, the Forgiver?"*
> *(39: 5)*

As Islam spread across the Afro-Eurasian continental belt, people from distant lands needed to make the *Hajj* or pilgrimage to Makkah as one of their basic religious obligations. A thorough knowledge of the stars was one of the most critical tools for these early travelers. Muslims also needed a thorough understanding of the *calendar* for religious reasons. They soon learned to draw upon mathematics and astronomy to accurately compute times for such rites as the five daily prayers, times for fasting and the proper dates for the *Hajj* to Makkah. Muslim astronomers developed elaborate star charts called *zij* which served as the building blocks of both lunar and solar calendars. They eventually developed a lunar calendar which best served their religious needs the way a solar calendar cannot. Muslim scientists also produced popular calendars used as guides to farmers. These calendars, called *al-manakh* ("the climate") in Arabic, served as the model for the Farmers' Almanac which is still published each year in the West.[7] It might seem surprising, but the 11th-century scientist al-Biruni wrote a treatise of several hundred pages on the mathematics of shadows in order to correctly calibrate sundials for various locations and seasons.

Scholars working in 9th-century Baghdad translated the works of the ancient Greek astronomer Ptolemy, opening a whole new era in the science of the heavens. Some of the greatest astronomers in history translated the works of Ptolemy (particularly his *Almagest*) into the Arabic language. With these translations preparing the foundation of their research, astronomers working under Muslim patronage made corrections of Ptolemy's works, expanded upon his theories and gained the confidence necessary to develop their own theories about such issues as the nature of heavenly spheres, planetary motions, the distance and size of planets, and the relationship between time and mathematics. It is likely that the *Almagest* that was so prized in Europe, with its maps, longitude and latitude and descriptions of the earth, was quite different from the work that had been left

7. Nasr, ***Islamic Science, An Illustrated History***. (Westerham, Kent: World of Islam Festival Publishing Company Ltd., 1976), p. 96.



This 12th-century drawing in Liber Experimentarius shows Hermann of Carintha, one of the medieval translators of Arabic texts, holding an astrolabe. He is shown sitting with Euclid, who is holding a dioptra. The dioptra was a proto-telescope, a lensless tube with sliding plates used to measure the angle and diameter of stars.

in post-Roman times. It had been updated and enhanced by the geographic studies, cartography, mathematics and astronomical studies that had been done by scientists in Muslim lands, based on Ptolemy's original system.

Using this information, Muslim scholars also improved and developed measuring instruments such as the astrolabe and the quadrant, which revolutionized travel and exploration because they enabled people to determine their exact location on the earth, calculated by the position of the stars. The importance of these developments becomes clear when one considers how unwilling they were to jump on a ship headed toward the open sea before these instruments were created!

Under the patronage of al-Ma'mun, the 9th-century caliph of Baghdad, scholars continued to expand the Muslim understanding of the cosmos with such great intellects as al-Khwarizmi and Abu Ma'shar bringing more accuracy to the star tables that scientists were using as the basis of their studies. Abu Ma'shar was often quoted by Renaissance scientists. His manuscript, *Great Introduction to Astronomy* served as a guide to European university students for centuries. Al-Faraghani, who is known as Alfraganus in the Latin West, wrote another critical textbook for scientists called *Elements of Astronomy*, in addition to his work in mathematical geography.

The 9th-century scholar al-Battani (Albategnius to the Latin West) is the man whom some consider the greatest of all Muslim astronomers. He studied the movement of the sun and offered a scientific explanation of eclipses of the sun and the moon. (Before this, eclipses were seen as a frightening sign of God's anger.) His works were used by western astronomers all the way into the 18th century when Dunthorn did his famous studies of the movements of the moon. Another Renaissance scholar, C.A. Nallino, wrote lengthy commentaries on the star tables of al-Battani.[8]

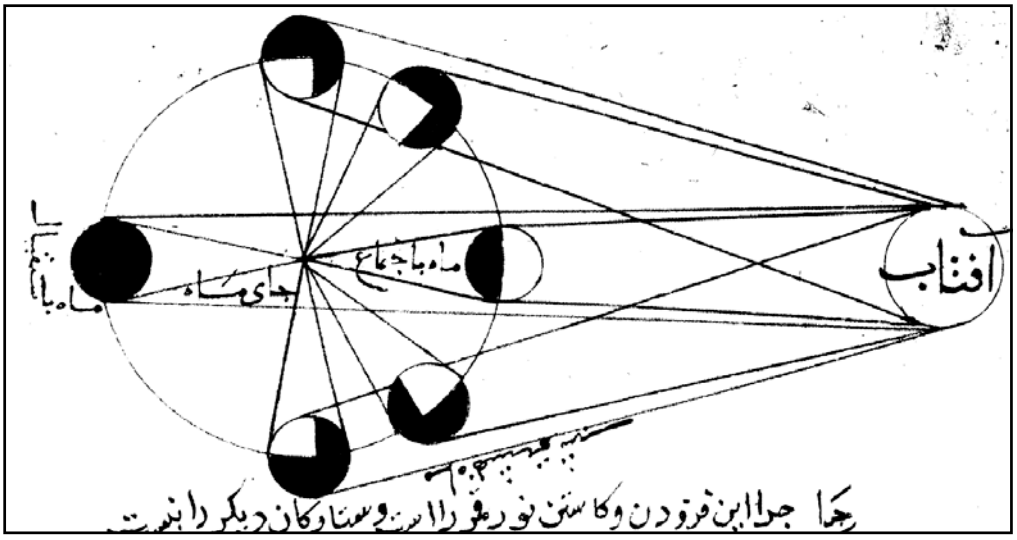
The 11th century saw the ascent of al-Biruni, who was skilled at determining latitude and longitude. His writings include a description of India's geography and his famous work *The Coordinates of Cities*, which are quite accurate even by today's standards. Working in the royal courts of Medieval Cairo was Ibn Yanus who solved problems in spherical trigonometry and did detailed studies of the rhythmic swinging of pendulums. This study led to the development of mechanical clocks.

Scholars were also busy in Islamic Spain where Jews and Muslims refined the *zij*, or star tables, even more. Jabir ibn Aflah wrote criticisms of Ptolemaic (Greek) astronomy. While he did not propose an alternative model, his writings inspired Renaissance scholars to cast off their dependence upon Ptolemy's astronomical model and develop their own theories. Jabir and other Muslim astronomers' works were prized possessions that were known to have been part of noted European astronomers' libraries, including a copy that was presented to Copernicus. Again, many of these works only became widely known with the advent of printing during the Renaissance, even though they had been translated centuries earlier.[9] In his *Memorial to Astronomy*, al-Tusi proposed a new idea of the nature of heavenly spheres which placed the earth closer to the center of the rotating planets than Ptolemy the Greek had done. Muslim scientists refined al-Tusi's theory of lunar (moon) motions for two more centuries so that when Copernicus proposed to Renaissance scholars his revolutionary theory, he essentially repeated what had been proposed by al-Tusi and his students two centuries before.

Muslim rule had been driven out of Spain by the Christians, who united in the north and swept toward the southern region of the country—the region the Arabs called *al-Andalus*. There were, however, some Christian

8. Nasr, *Science and Civilization in Islam*, (Cambridge, MA: Harvard University Press, 1968), p. 170.

9. Lisa Jardine, *Worldly Goods: a New History of the Renaissance*, (New York: Nan A. Talese/Doubleday, 1996), pp. 363.



Al-Biruni's diagram of lunar eclipses.

rulers, such as Alfonso the Wise, who continued the tradition of courtly scholarship. This 13th-century scholar-poet king ordered the works of Ibn Haytham (Alhazen) and other Islamic scholars to be translated into Spanish. Passages such as the following—concerning the heavens of the fixed stars—offered inspiration to scientists in Europe to further develop the science of the stars:

> ❝ *…(they are) a round globe, enclosed with two spherical surfaces, whose center is the center of this globe and of the world. The external surface of this globe is contiguous with the largest of the heavens, the one which encloses all the moving heavens and involves them in its rapid movement; the internal surface of the same globe touches the orbit of Saturn. This heaven turns from the West to the East, according to the order of the signs on two fixed poles. Its movement is slow: during each hundred years it moves only one degree, while the whole circle is divided into three hundred and sixty degrees.*[10] ❞

Works such as the one quoted above were eventually translated into Latin and studied by young scholars who attended the great universities of Latin Christendom. Manuscripts of scholars who had studied under Muslim patronage served as the basis for European astronomical studies until the 17th century. Edmund Halley (for whom Halley's Comet is named) studied astronomy in Oxford, England, primarily by referring to texts which existed only in Arabic because their Latin translations had been lost through the centuries.

Muslim scholars also gave us many of the words used by modern astronomers such as *zenith*, *azimuth* and *nadir*. They also provided us with names of constellations and stars such as Aldebaran, Altair, and Betelgeuse, as the Latins called the bright red light in the shoulder of the constellation Orion. Betelgeuse was discovered by an Arab who named it *Bayt al-Jizyah* or the "House of Jizyah". Children today know this star as "Beetlejuice".

Through Muslim mastery, astronomy became a clear and precise science, but Muslim scholars did more than simply develop the tools needed to mathematically explain the movement of heavenly bodies. In the Muslim minds and hearts there was much more than the physical heavens we can see with the naked eye. There was, in a deeper sense, the heavens inhabited by God and angelic beings. To them, the sun, moon and stars were also to be revered as visible manifestations of God's glory—majestic signs of the continual presence of God's guidance. When gazing at the huge night sky, filled with glorious constellations and blazing shooting stars, a devout Muslim cannot help but recall the beauty of chapter 2, verse 115 of the *Qur'an*:

> ❝ *To Allah belong the East and the West: wherever you turn, there is Allah's Face. For Allah is All-Embracing, All-Knowing.* ❞

10. Nasr, p. 177.

ZOOMING IN ON HISTORY

THE GREGORIAN CALENDAR

THE earliest annual calendars were lunar calendars, based on the phases of the moon. They were needed mainly for agricultural purposes *and* for determining times of religious holy days. Hundreds of different calendars were developed by different cultures throughout time, creating massive confusion. The Roman Emperor Julius Caesar saw the need to develop a stable, predictable calendar and with the aid of an astronomer named Sosigenes, this Roman leader corrected some errors by giving 445 days to the year 46 BCE. Each year after that was to have 365 days. However, this effort to correct mistakes failed to factor in the proper amount of leap years, such as those we still use today to correct our calendar every four years. (We add one day to our calendar every 4th year to adjust for imperfections in the 365 day calendar.) Eventually these early calendars became more and more inconsistent with the intended times of holy days.

By the 16th century, the calendar had become so out of sync that religious holy days were nowhere near their original place within the annual astronomical cycle. This caused the leadership of the Christian church to become alarmed by the inaccuracies of the Roman calendar. Their main point of concern was the lack of exactness in setting dates of Christian Holy Days. The date of Easter, for instance was supposed to be determined by the Spring Equinox, the first day of Spring when the sun is exactly over the equator (approximately March 21). With the passing of time and the resulting inaccuracies, Easter eventually fell nowhere near the Spring! In response to this grave concern, Pope Gregory VIII called a meeting of church and civic leaders in which he called for a calendar that would definitively set times for Holy Days *and* remain constant throughout time. Copernicus was one of the scholars he called upon.

When the Pope and Christian leaders sought an accurate star chart to serve as the basis of this calendar, they turned to one designed by Ulugh Beg, the 15th-century Muslim ruler of the "Golden City of Samarkand" in Central Asia. This city was a showpiece of Islamic city planning because it had followed the Islamic tradition of centering the town with an open square surrounded by a palace, schools, a mosque and a nearby market. Samarkand was the proud creation of Ulugh Beg's grandfather, Timur the Lame (Tamerlane), a warrior who was known for his ruthless slaughter of those he defeated. (In fact, his mausoleum sports an inscription which proudly states "*If I were alive today, people would not be happy*".)

Although Tamerlane is most famous for his military conquests, he was also respected as an accomplished builder and patron of learning who brought glory, wealth and scholarship to Samarkand. His grandson Ulugh Beg was a great warrior as well, but in addition to his military expertise, he also followed his grandfather's footsteps in scholarly pursuits, developing tremendous skills in architecture, mathematics and astronomy. In the 1420s he built a planetary observatory so accurate that *without the aid of a telescope*, this scholar-king was able to map the positions of more than 1220 stars. Ruins of this observatory are still visible at Samarkand.

Pope Gregory VIII turned to Ulugh Beg's star charts when he ordered the development of a systematic method of setting dates. This calendar, which we still use today, is called the Gregorian Calendar and was introduced on Friday, October *15th*, 1582, the day after Thursday, October *4th*, 1582! It seems that a little "adjustment" needed to take place before the calendar could be put into use.[11]

11. Based on information from Grolier Electronic Publishing, Inc., 1995 *Grolier Multimedia Encyclopedia* and *Aramco Magazine* special issue, Traveling the Silk Roads, July-August, 1988.

CONTRIBUTIONS OF MUSLIMS TO THE FIELD OF MEDICINE

In the field of medical knowledge, Muslim scientists had several sources on which to base their studies. The first source was Islamic teachings, including many religious requirements concerning hygiene. In addition, there is a saying attributed to Prophet Muhammad that for every disease, God has created a cure. The second source of learning was the body of Greek medical knowledge, developed by Hippocrates and Galen. These contributions were easily integrated into the study of Muslim medicine due to their focus on harmony and balance. A third source was the traditions practiced by Persians, Indians and others who practiced medicine at the teaching center of Jundi-Shapur (Iran). Both Jundi-Shapur and Baghdad had well developed "teaching hospitals" which attracted physicians from afar to study under famous teachers. Among the physicians who helped found the teaching hospital at Baghdad were the Bakhtishu family of doctors, non-Muslims who worked under the patronage of the Muslim rulers.

Links Between Islamic Belief and Medical Practice

An instrumental aspect of Islamic theology is the *divinely-ordained balance of life*. This can be viewed through both a microcosmic window (looking at the smallest details) and a macrocosmic window (viewing the "big picture" of how all elements, up to the highest level are related). For instance, a scientist can look at a plant and recognize the vital, life-giving balance between the plant, the small living organisms which survive on the surface of the plant, and the fresh air which the plant needs in order to live. It is clear that the plant is part of a relationship that "re-cycles" elements that make up fresh air, sunlight for photosynthesis, and the nourishment of the soil and the water. If just one of these elements is missing, the whole plant would cease to exist.

On a higher level, Muslims point to the relationship between the divine world (including angelic beings) and the physical world which is inhabited by people. It focuses on the human need to transcend the physical world and reach for a higher plane where one can obtain a purer state of existence in which one can understand the origin and principle of the universe. This field, sometimes called "Islamic Cosmology", draws upon the wisdom of *Qur'anic* revelation, *Hadith* (sayings of the Prophet Muhammad), universal symbolism, philosophical descriptions of the cosmos, the ancient symbolism of numbers, and traditional astronomy.[12]

12. Nasr, ***Islamic Science, An Illustrated Study***, (Westerham, Kent: World of Islam Festival Publishing Company Ltd., 1976), p. 31.

The Islamic Sources

When looking at the practice of Muslim medicine, one must keep in mind that it is considered a Prophetic Medicine, based on a divine message passed down to humankind through the Prophet Muhammad. There are many *Qur'anic* verses which point to the elements of a healthy, well balanced world as a sign of Allah's mercy, power and majesty. The *Hadith* (sayings of the Prophet Muhammad) and *Shariah* (Islamic Law) were important sources of Islamic medical practice:

> *"According to al-Tirmidhi, the Prophet said: "He who wakes up in the morning healthy in body and sound in soul and whose daily bread is assured, he is as one that possesses the world." "*

> *"Al-Nasa'i relates that the Prophet said: "Ask God for forgiveness and health. After security of faith, nothing better is given to a man than good health." "*

The sayings of the Prophet Muhammad, as well as Islamic Law, served as guides to Muslim physicians. There are *many* collections of the traditional sayings of the Prophet Muhammad on the subject of medicine. These volumes link all three major sources of Muslim medicine into a whole, made up of elements of *Qur'anic* revelation, Prophetic traditions and the *Shariah*, or Islamic Law. Muslim religious law gives a great deal of guidance in the field of personal hygiene. The simplest example is the fact that Muslims must perform ablutions (cleansing) before prayer in order to approach prayer in a physically as well as spiritually pure state. This is done at least five times per day. Brushing teeth at least daily is recommended. Regular bathing of the whole body, at least once per week, and wearing of clean clothes ensured a high standard of personal hygiene even for the poor.

Muslim scholars prepared extensive and detailed books which served as guides to physicians who wished to treat their patients in a manner which remained within the parameters of Islamic practices and law. One of the more influential of these books is the *Tibb al-Nabi*, or "Medicine of the Prophet" by Jalal al-Din al-Suyuti. Al-Suyuti was born in Egypt in 1445 CE. Showing brilliance even as a child, he had memorized the entire *Qur'an* by the age of eight. Fortunately for modern scholars and physicians, he was a prolific writer and accomplished the important task of summarizing several centuries of scholarship concerning recorded *Hadith* which deal with the issue of health care. His book is divided into three distinct sections and offers a wealth of information about medieval treatment of illnesses. In his opening passage, parts of which follow, al-Suyuti clearly presents the link between religion and health care:

> *"In the name of God, the Beneficent, the Merciful. Praise be to God who has given existence to every soul and has inspired each towards good acts and bad acts, and has taught what is for their good, what is for their harm, what causes sickness and what causes health, and has given death and bestowed new life…*
>
> *It is obligatory upon every Muslim that he draw as close to the Almighty God as he can and that he put forth all his powers in attention to His commands and obedience to Him and that he make the best use of his means and that he succeed in drawing near to Him by conforming to what is commanded and refraining from what is forbidden and that he strive for what gives benefit to Mankind by the preservation of good health and the treatment of disease. For good health is essential for the performance of religious obligations and for the worship of God.[13] "*

13. Cyril Elgood, transl., ***Tibb ul-Nabbi of Al-Suyuti, The Medicine of the Prophet, by al-Suyuti.*** (Cooksville, Tennessee: Tennessee Polytechnical Institute, n.d.), p. 48.

Because it was a religious obligation to take care of one's health, Muslim physician-scholars, referred to as *Hakeems*, were influential and valued citizens throughout the Muslim lands. These *Hakeems* passed on to others the great wealth of medical knowledge which the Muslims were developing with the help, in particular, of Christian and Jewish physicians. Great medical schools were attached to hospitals throughout the Muslim lands at cities such as Jundi-Shapur in Persia, Baghdad, Damascus, Cairo, and Cordoba. Supported by religious endowments called *waqfs*, the teaching hospital became the focus of scientific research in Muslim lands. *Waqfs* also supported the construction and upkeep of public baths and municipal drinking fountains, indicating an early understanding of the vital link between personal hygiene, clean drinking water, and physical well being. Many of these fountains and baths, called *hammams*, were so critical to medieval Muslims that they were constructed with the intent to provide centuries of service to the populace. When medieval writers described Islamic cities, a critical element of their narration was an indication of the number of *masjids* (mosques), libraries, fountains and public baths in a given city. For example, *hammams* numbered in the hundreds in Baghdad and other urban centers. Though some of the other buildings may have crumbled with time, well-maintained baths and fountains which are several centuries old still stand in cities such as Fez, Damascus, Tehran, Istanbul and Cairo.

The Theory of Muslim Medicine

Muslim physicians saw the human body as an extension of the soul. Like those who practiced traditional medicine in cultures such as those of India and China, Muslims also believed that there was a clear link between cosmic forces and the well being of humans. **This natural and delicate balance between all created things forms the basis of traditional Islamic medicine**. This view assumes that good health is the natural state, and illness is the result of an imbalance. Using the language and concepts developed by the Greeks, Muslim scholars expanded upon the idea that a person who had become ill had lost the delicate balance between the "good humours" and the "bad humours." It was thought that with the restoration of this critical harmony, the illness would disappear, and good health would return.

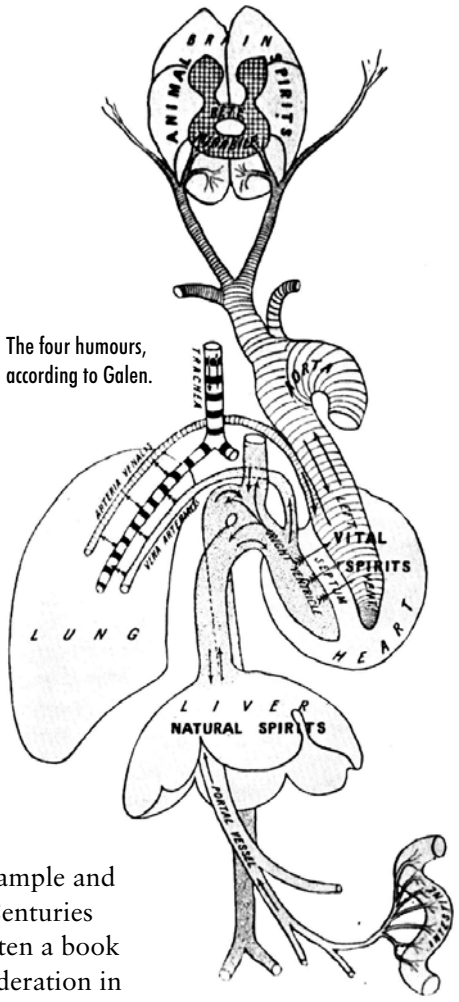
Greek theory held that a healthful human body is based upon the complex balance and harmony of the following: *the four humours*, that is, **blood**, **phlegm**, **yellow bile** and **black bile**; *the four natures* of **hot**, **dry**, **cold** and **humid**; and *the four elements* of **earth**, **water**, **air** and **fire**.[14] These concepts—widely prevalent at the time—were integrated into Muslim medical studies.

It was believed that each individual had their own temperament, based upon either the balance, or imbalance of all these elements. Diseases were associated with certain humours, so that if one were suffering from a disease which affected the yellow bile, which is hot and humid, they were to be treated with things which are dry and cold, such as certain foods, herbs and medications. Al-Suyuti explains these elements in his *Tibb al-Nabi*:

> *The Constitution of Man is concerned with seven components. The first component is the Elements which are four in number—fire, which is hot and dry, air which is hot and wet, water which is cold and wet, and earth which is cold and dry.*
>
> *The second component is the Temperaments which are nine in number. The first is an evenly balanced temperament. The second is an unevenly balanced temperament, which may be unmixed, being then hot, cold, damp, or dry. Or it may be an unevenly balanced but mixed temperament…*

14. Nasr, ***Islamic Science, An Illustrated Study***, p. 160.

Next among the seven components of the Constitution come the Four Humours. Of these the most excellent is Blood, which is damp and hot. Its property is to feed the body. Next comes Phlegm and this is wet and cold. Its property is to convert blood whenever the body lacks food, to keep the organs damp and to prevent drying up due to movement. The third humour is Bile which is hot and dry. It is stored in the Gall Bladder. It renders the blood subtle and helps it to pass through the very narrow channels. Finally, there is the Spleen. This is cold and dry. It thickens the blood and feeds the spleen and the bone. Spleen is sometimes called Black Bile.[15] ❞



The four humours, according to Galen.

The importance of *psychological* health and its relationship to one's physical well being was also understood by the Arabs as early as the 8th century. Concerning the psychological state of people, al-Suyuti wrote:

❝ *The body is indeed changed by emotions. The emotions include: ANGER, JOY, APPREHENSION, SORROW, SHAME.* ❞

People were advised by al-Suyuti to follow the Prophet Muhammad's example and turn to God for refuge when suffering from apprehension and sorrow. Centuries before al-Suyuti, the famous physician al-Razi (Rhazes in Latin) had written a book of essays on maintaining health, called *Spiritual Healing*. He advised moderation in food and drink, and avoiding anxiety, anger, and excessive behaviors of all kinds.

In an effort to improve the psychological condition of patients, the famous 10th-century Adudi hospital in Baghdad offered soothing music, poetry and the sound of running water to calm people down and speed recovery. In an early form of "Social Services," patients also received a small sum of money upon their release from the hospital in order to facilitate a smooth transition back into the community. The poor were treated free, and gardens were available, not just for growing fresh herbs for the hospital pharmacy, but also for the recreation and refreshment of recovering patients.

A Combination of Treatments

Muslim physicians treated their patients with a combination of diet management, medication, isolation of contagious diseases, prayer, fresh air, healing scents, and reduction of psychological stress.

❝ *O ye who believe! Eat of the good things that We have provided for you. And be grateful to Allah, if it is Him that you worship.* ❞ *(Qur'an, 2:172)*

Because many foods such as pomegranates, lentils and olives are specifically mentioned in the *Qur'an*, diet was a particularly critical element of a patient's treatment. Again, physicians drew upon the wisdom of the Prophet. Al-Suyuti's *Medicine of the Prophet* lists page after page of descriptions of the medicinal properties of specific

15. Elgood, pp. 49-50.

foods. For example, limes are said to be hot and dry within the peel and the seed, but the leaf is considered cold: therefore, the leaf should be administered to a person with problems of heat-related illnesses of the blood and yellow bile. Limes were used to cut phlegm, destroy bile, and reduce vomiting. The healing and calming qualities of floral and wood scents were also listed, such as violet and sandalwood to reduce headache, and frankincense to fumigate the air of homes.

The Influence of Muslim Medical Theories on European Practice

Physicians in medieval Europe also adopted from the East the concept that people had certain "humours" or personality types, and that these humours could offer a physician clues about diet and the treatment of illness. Disease was thought to be the result of excess of heat, cold, dryness or humidity. The patient's diet was usually the focus of treatment. As in many other cultures, the links between the four humours, four elements and the four natures as well as the zodiac are clearly depicted in medieval European manuscripts, art and folklore. This was the prevailing *paradigm*, or explanatory model, of the age.

The "good health diet" was supposed to maintain a proper mix of humours suited to the temperament of the individual. But initially treatment was rendered in the complete opposite way than the Arab physicians would have proceeded. European physicians believed that those who were "warm" by nature, were naturally attracted to hot foods, and hence, in contrast to what the Arabs would have suggested, were encouraged to follow their desires and eat "hot" foods when feeling ill. (Arab physicians would have suggested eating "cold" foods, to restore the patient's balance.) Europeans were following the advice offered in the book *Regime of the Body*, written in the 13th century by Aldebrandino of Sienna. This practice continued to be the dominant method of treatment in Europe up to the 16th century.

Healing Through a Combination of Religious Faith, Folk Tradition, and Superstition

In describing links between Christian theology and the study of medicine, Grollier's *The History of Medicine* makes the following statement:

> *"During the Middle Ages the influence of Christian theology affected medicine in several ways. The Christian emphasis on charity and concern for the sick and injured led to the establishment of hospitals often related to and maintained by monastic orders. In the later Middle Ages, spacious, fine hospitals were built by the Knights of St. John, including Saint Bartholomew's in London and one at Rhodes. The concern of Christian theology, on the other hand, was to cure the soul rather than the body; disease usually was considered supernatural in origin and cured by religious means. As a result, scientific investigation was inhibited during this time. Brothers of various monasteries copied and preserved those scientific manuscripts and documents which were thought to be consistent with prevailing religious thought, notably the works of Galen and Aristotle.[16]"*

Both Arab and European cultures have strong folk traditions of using superstition, magic, astrology and amulets to cure ills. Even with all their advances in the field of medicine Muslim physicians, like their European counterparts, continued to turn occasionally to these folk traditions as healing aids. For instance, Islam developed in a region where people believed that they could be struck by the "Evil Eye". (This belief developed in

16. Grollier 1995 *Electronic Encyclopedia*, "The History of Medicine."

pre-Islamic Arabia during the era Muslims refer to as the "Time of Ignorance".) This tradition continued after the rise of Islam, and is prominently dealt with in al-Suyuti's *Medicine of the Prophet* where the following advice is offered:

> *"If any one of you is struck by the Evil Eye and asks for water in order to perform an ablution (ritual cleaning) then his request should be granted. And he who is struck by the Evil Eye will wash his face, his hands, his elbows and knees, and the tips of his feet, and what lies within his breeches. He will collect this water in a cup and pour it over the possessor of the Evil Eye. He will turn the cup upside down behind him on the ground. It is said the this pouring upon him will bury the effects and he will be cured by the permission of Almighty God. So it is said by the Imam Malik in his al-Muwatta.*[17] "

Although their religious validity was strongly debated among Muslims, astrology, numerology (belief in magical qualities of numbers), charms and amulets also continued to be used in medieval times to protect one from evil and illness. During the time of the Black Plague in particular (which reached its peak in the mid-1300s), Christian and Muslim population centers were so devastated by the disease that people turned to every available cure possible. They sought refuge in both superstition and in their religion, often making little distinction between the two. Wealthy Christians carried on their bodies small vials of glass which held what were thought to be the tears of the Blessed Virgin Mary. Some carried relics, such as a bone or piece of hair of a saint, which they purchased on religious pilgrimage. Poor people had to make do with the bone of a frog's head or the tongue of a poisonous snake. Another "sure remedy" was to wait until the stomach was empty and eat a piece of paper inscribed with prayer, and folded seven times.[18]

Muslims frequently wore amulets and rings which had Arabic letters inscribed on them. These letters were thought to have protective qualities because the *Qur'an*, which is considered the literal, unchanged word of God, was handed down to mankind in Arabic. *Qur'anic* passages such as those below indicated to the devout that wearing letters or carrying written verses of the *Qur'an* in their clothing would safeguard people from the plague:

> *"We sent down (stage by stage) of the Qur'an that which is a healing and a mercy to those who believe…" (17:82)*

> *"Say: "It (the Qur'an) is a guide and a healing to those who believe." (41:44)*

> *"We have sent it down as an Arabic Qur'an in order that ye may learn wisdom." (12:2)*

17. Elgood, pp. 63-64.

18. E.R. Chamberlain, ***Everyday Life in Renaissance Times***, (New York: Capricorn Books, 1967), p. 133.

The Exchange of Ideas

The two greatest times of rapid exchange of medical knowledge between the Islamic Empire and Latin Christendom took place during the Crusades (11th-13th centuries) and the Black Plague (14th century). We can learn much about the exchange of medical information by studying the writings of those people who wrote chronicles describing their experiences. One of the most famous essays written about the differences between European and Arab treatment of the sick and wounded is the following chronicle written by Usamah Ibn Munqidh, a prominent Syrian Muslim who wrote during the time of the Crusades. (It is interesting to note that Usamah's story relates the experience of a highly respected Christian physician who was practicing medicine among the elite Muslims of Syria at that time.):

One day, the Frankish (French) governor of Munaytra, in the Lebanese mountains, wrote to my uncle the sultan, asking him to send a physician to treat several urgent cases. My uncle selected one of our Christian doctors, a man named Thabit. He was gone for just a few days, and then returned home. We were all very curious to know how he had been able to cure the patients so quickly, and we besieged him with questions. Thabit answered:

"They brought before me a knight who had an abscess on his leg and a woman suffering from consumption (excessive fatigue and general poor health). I made a plaster for the knight, and the swelling opened and improved. For the woman I prescribed a diet to revive her constitution. But a Frankish doctor then arrived and objected, 'This man does not know how to care for them.' And, addressing the knight, he asked him, 'Which do you prefer, to live with one leg or die with two?' When the patient answered that he preferred to live with just one leg, the physician ordered, 'Bring me a strong knight with a well-sharpened battle axe.' The knight and the axe soon arrived. The Frankish doctor placed the

Muslim physician treating a Christian knight.

man's leg on a chopping block, telling the new arrival, 'Strike a sharp blow to cut cleanly.' Before my very eyes, the man struck an initial blow, but then, since the leg was still attached, he struck a second time. The marrow of the leg spurted out and the wounded man died that very instant.

As for the woman, the Frankish doctor examined her and said, 'She has a demon in her head who has fallen in love with her. Cut her hair.' They cut her hair. The woman then began to eat their food again, with its garlic and mustard, which aggravated the consumption. Their doctor affirmed, 'The devil himself must have entered her head.' Then, grasping a razor, he cut an incision in the shape of a cross, exposed the bone of the skull, and rubbed it with salt. The woman expired on the spot. I then asked, 'Have you any further need of me?' They said 'No', and I returned home, having learned much that I had never known about the medicine of the Franj (French)."[19]

Specific Contributions of Islamic Medicine[20]

By the late 16th and early 17th century, European medicine had begun to adopt a different treatment of disease from the earlier European traditions. They relied on encyclopedic works like the *Canon of Medicine* by Ibn Sina (Avicenna) and the *Book of Mansur*, al-Razi's major work under the *Khalifah's* patronage. These works described diseases and treatments systematically and thoroughly, in a scientific manner that still holds up even today. Differential diagnosis, testing of cures, and carefully recorded clinical results were hallmarks of the works of these two giants of science whose place in history has been universally recognized. These and a large number of other works, including Al-Zahrawi's *Encyclopedia of Surgery and Instruments*, and pharmacology encyclopedias by numerous authors, as well as translations of the best Greek works, such as those of Galen, had all appeared in print by 1500 CE. Of the hundred or so known Muslim scientific works printed in the first century of printing, about 30 of them were on the topic of medicine. They were standard textbooks in all the universities through the 17th and 18th centuries.

Europeans adopted the Islamic medical theory that people should be treated with a diet that *restores the natural balance*. In other words, people should be restored to equilibrium through food and medicine rather than indulged in their cravings and desires. The *Tresor de Sante*, written in 1607, maintained that foods and drinks "that are humid and warm in quality" should be given "to those of melancholy humour" (that is, dry and cold). "Warm and dry" foods should be given to those of a phlegmatic (cold and humid) nature, and so on.[21]

The development of medical sciences within the broad Islamic world led to great advances which influenced European healthcare for centuries. Following is a partial list of medical advances made by scholars working within the Muslim realm:

■ Translation and Transmission of Medical Knowledge

Arab scholars translated Greek, Persian and Indian texts into Arabic. After making corrections and commentaries and adding new discoveries, these books were later translated into Latin and passed on to Europe where they served as the major texts for European medical schools. Arabs saw the links between diet, psychology, a healthy lifestyle and human wellness. They established "teaching hospitals" which served as a proto-type of today's hospitals that contain medical schools, libraries, pharmacies and laboratories. The basic foundations of the field of Pharmacology were formed.

19. Amin Maalouf, *The Crusades Through Arab Eyes*, (New York: Schocken Books, 1984), pp. 131-132.

20. Section adapted from John Hayes, *The Genius of Arab Civilization, Source of Renaissance*, (Cambridge MA: The MIT Press, 1983), pp. 173-186.

21. Philippe Aries and Georges Duby, *A History of Private Life, Passions of the Renaissance*, (Cambridge: Harvard University Press, 1989), pp. 294-295.

■ The Philosophy and Theory of Medicine

Hunayn ibn Ishaq (809-873), director of Baghdad's *House of Wisdom*, wrote the *al-Masa'il fi al-Tibb* ("Introduction to the Healing Arts") which was later translated into Latin as the *Vade Mecum of Johannitius*. This book, and others like it, influenced theories of medical care in Latin Christendom. He is also the author of an anatomical and detailed study of the eye, among many other works.

■ Clinical Medicine

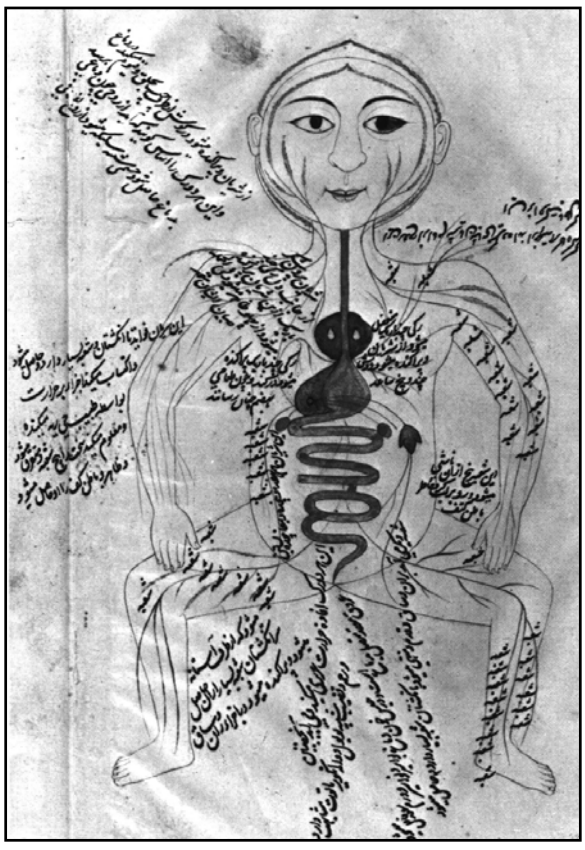
Scholars in the Muslim tradition made advances in diagnosing and treating smallpox, measles, eye diseases, skin diseases and other ailments. Advances were made in nutrition, mother and child care and the use of drugs to cure illness. They also wrote about the effects of environment on health. It was Muslim physicians who realized that diseases are contagious and hence, should be isolated within specific hospital wards. They set the standards for medical experimentation and clinical observation. Ibn Sina (980-1037), known as Avicenna in the West, wrote the monumental *Canon of Medicine* which listed every known disease of the time as well as its cure. This publication served as the major medical school textbook in European universities well past the Renaissance.

■ Opthamology

Due to the hot, dusty setting of the Middle East, medieval Islamic medical records reflect a high incidence of eye diseases such as trachoma and opthalmia. The Arab advances in eye care were not surpassed until the 17th century. Studies were conducted on the anatomy of the eye, the brain and the optic nerve, bringing a clear understanding of the elements of vision. (Until this time, scientists believed that vision was caused by rays which were sent *out* of the eye, instead of understanding that sight is the result of light rays going *into* the eye and being directed by optic nerves to the brain.) Muslim eye surgeons were able to remove cataracts by use of a hollow needle and suction, a procedure which was revived in 1846 by a French doctor.

■ Surgery, Anatomy and Physiology

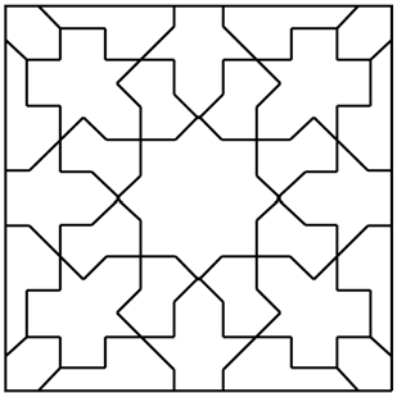
Arab physicians had a clear understanding of the pulmonary circulatory system, discovering the lesser circulation of the blood and smaller vessels. They also described the four chambers of the heart and explained the working of heart valves and how they kept blood flowing in one direction. They invented sedatives and narcotic drugs which enabled them to perform surgery, for which they invented over 200 instruments. Sutures (stitches) were made of animal intestines and silk. Antiseptics such as alcohol (from the Arabic word *al-kohl*) enabled surgeons to reduce the risk of infection.



Persian book on anatomy shows blood circulation.

■ Pharmacy and Pharmacology

This field became a separate science for the first time in history under the leadership of people such as Sabur bin Sahl (died 869) who wrote the earliest known book of medicinal recipes in Islam. Drugs, herbs and spices from Africa to China were categorized and studied in a scientific manner. Case histories were written to track the success of treatments. Due to the religious belief that Allah has created a natural cure for every disease, scientists within the Islamic empire focused their studies on the use of natural remedies. For this reason, many hospitals had herb gardens adjacent to them, and pharmacies for mixing fresh and potent remedies. Among the other important scientific advances that aided pharmacology were horticulture, or the science of gardening, and chemistry, which aided in the discovery and preparation of natural substances. Chemists discovered ways to purify, isolate, and concentrate these substances. Muslim pharmacists also gave the world syrup-based medicines that made them easier to take, as well as ointments, compounds, essences, and tinctures. One contribution that is particularly useful for modern-day hikers is a medicine for insect bites—calamine lotion—which takes its name from the Arabic word for zinc.



METALWORK, GLASS AND CERAMICS:

EXPORTING TECHNOLOGY, STYLES AND GADGETS

It is common to read about the contributions of Muslim scientists in fields like medicine, mathematics and astronomy, which European historians have finally acknowledged. The field of technology, however, has not been studied widely until recently. In connection with historians' recent interest in the importance of certain inventions in European history, the Muslim world has begun to be recognized as a source for technological innovation as well. The water wheel and the windmill, the technology of irrigation and large-scale farming, navigation instruments, weapons of war, methods of mining and smelting and working metals, glass and ceramic techniques and a whole range of processes in manufacturing textiles—looms, dyestuffs, fixatives and sizing materials—all of these technologies were required to make the luxury products for export and local use in Muslim lands. The sheer size of the territory involved in active communication, the high level of urbanization, and the prosperity of Muslim lands implied a certain level of advanced technology. Looking at the number and size of Muslim cities, we can infer the level of technology and land management needed to supply them with surplus food from rural areas. Supplying food for the populace involved other activities on a very large scale, including transport, processing (milling and grinding, butchering, etc., including quality control), and preservation (salting, drying, pickling, cheese-making, etc.). Textile manufacture was another way that technologies from a wide variety of cultural regions were brought together and pursued on a grand scale for residents and for export. Supplying and arming military forces involved not only food, textiles and a wide variety of goods for equipment, but also a very sophisticated steel industry with production and mining centers at various locations. These same mining and metalworking centers supplied the needs of cities for household hardware and artisans' tools, for shipyards, and for the luxury market in utensils, trinkets and ceremonial objects and buildings. A quotation from technology historians Ahmed Hassan and Donald Hill makes this clear:

> *"When people speak of the splendor of Granada or Baghdad, they are referring in fact not only to their artistic grandeur but also to the high level of their technology. This is true, too, of the Crusades, where Islamic successes also depended to no small extent on technological advances.[22]"*

Technological expertise was also a very mobile commodity in Muslim lands. Artists, artisans, writers, scientists, scholars, merchants and even people of the common classes, Muslim and non-Muslim, traveled extensively and carried with them cultural traditions, knowledge and skills that contributed to the mingling of technical expertise within Muslim culture. Writing about agriculture, historian Andrew Watson states:

> *"All through the literary sources from the medieval Islamic world are found accounts that suggest an almost incomprehensible amount of coming and going across huge stretches of land and water…Muslims from every region and of every station left home and roamed to and fro over the continents, taking with them knowledge of the farming techniques, plant life and cookery of their homelands and seeing on their way the agricultural practices, plants and foods of new lands.[23]"*

22. Ahmad Y. al-Hassan and Donald Hill, ***Islamic Technology***, (Cambridge: Cambridge University Press/Unesco), 1986), p. 280.

23. Andrew M. Watson, ***Agricultural Innovation in the Early Islamic World***, (Cambridge: Cambridge University Press, 1983), p. 93.

Andre Clot reiterates the idea of the Muslim world as a general medium for diffusion of technological and scientific knowledge in a chapter entitled "The Economic Miracle":

> *"The improvement of communications favored technical progress. Men had never traveled so much between the Atlantic and the Hindu Kush. Never before had goods and ideas circulated so freely.…Movements of populations, exchanges of prisoners, and wandering pilgrims diffused the available techniques, methods, and procedures; brought them into competition with each other; and exposed them to outside influences. Never had men exchanged so much in the way of products and know-how as in the years following the collapse of the great Sassanid empire, the loss of its Hellenic domains by Byzantium, and the accession of a new dynasty of caliphs in the Muslim world.[24]"*

When we read of a technology or invention that reached Europe from China, Asia or Africa before the Age of Exploration, such as gunpowder, paper, sugar, the brocade loom, the windmill, the compass or the astrolabe, that invention was first diffused through the Muslim lands. It was often further developed there, aided by the tremendous mobility and cultural receptivity to new things. In many cases, it is possible to plot the dates and places along which these innovations passed, using artistic, literary, documentary and sometimes archaeological evidence. (See *Paper Trail Map*, Segment 2, and *Botanical Travelers*, this Segment). Use of water and wind power for grinding flour, hammering pulp, pumping out mines and irrigating land was widespread in Muslim lands. Water distribution and irrigation works employed thousands to keep up high agricultural yields and urban water use.[25] By the late medieval period, such watermills and windmills were high-tech wonders just coming into use in Europe, so that we find them mentioned in poetry and other European literary works.[26] While Roman water power technology had fallen out of use across Europe, it continued to power agriculture in the arid Mediterranean lands, to which was added the windmill from Persia, and Chinese waterwheel technology from farther east. Spain was the likely point of diffusion for these devices into Europe, as the literary trail attests, including the scene of Don Quixote tilting at giant windmills.

The following pages show a variety of art objects and describe in detail the technological skills and knowledge required to produce them. The most remarkable aspect of this collection of gadgets and objects is the way they provide evidence of mobility across cultural and regional lines. They show how the European Renaissance was a time when Europe became fully linked into the nexus of coming and going that had already been in progress for several centuries in the Eastern Hemisphere. These objects give us the opportunity to look into the homes, palaces, workshops and public spaces of people at a specific time, and to view in detail the places and processes where these interactions among cultures took place. In addition, we have the opportunity to look closely at some remarkably beautiful things and see how they were made. In our age of electronic, automatic and instantaneous manufacture and communication, we can appreciate better these artisans' patience and dedication to their art, and the pace of life in earlier times and faraway places.

24. Andre Clot, (John Howe, tr.). *Harun al-Rashid and the World of the Thousand and One Nights*, (New York: New Amsterdam Pr., 1989), pp. 187-188.

25. Clot, pp. 186-188.

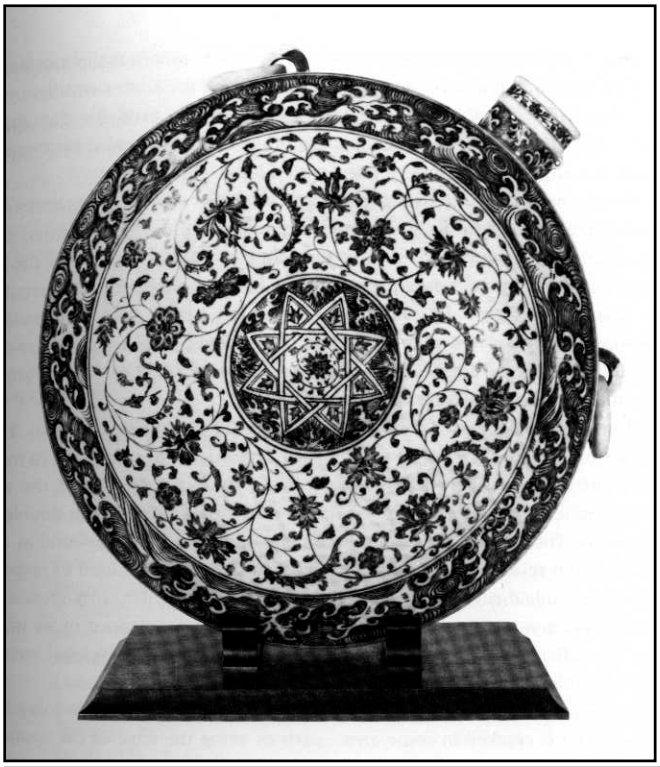
26. Jacques Le Goff, *Intellectuals in the Middle Ages*, (Cambridge, MA: Blackwell, 1993), p. 123.

1. Metalwork

■ Pilgrim Canteen, from 13th-Century Syria[27]

This spectacular and unusual piece was made for a Christian pilgrim to Jerusalem, who may have been a Crusader. The canteen was a form of container used by travelers to store drinking water since Roman times. The Muslim artisan made this one of spun sheet brass that was hammered, built in sections and soldered together. It is about 1 foot (37cm) in diameter, the largest known example. The canteen is inlaid with silver and highlighted with *niello* inlay (a hard black material). The Syrian or Palestinian craftsman decorated it with Arabic blessings for the owner as well as amazingly detailed scenes from the life of Christ, as well as saints and angels. On the other side, it also has fantastic animals, musicians, and riders, whose legs and arms make up the strokes of Arabic letters. A tournament with nine riders plays on another panel. To complete the large number of themes on this small space, the artist has added circles with swimming fish, and designs with planets and moons. Geometric bands and delicate designs connect the parts of the decoration. It is a mystery how the artisan managed to fit so much onto one object.

This canteen shows how two religions and two cultures met during the pilgrimage to the Holy Land, where a wealthy Christian pilgrim chose the best artist he could find, because "he wanted the largest and most spectacular 'pilgrim flask' to take home with him as a souvenir of his stay in Palestine."[28] Between the 1300s when it was made, and the 1800s when it was owned by Prince Filippo Andrea Doria, its history is not known. It is still in almost perfect condition after 700 years. It must have traveled all the way to China, however, because the Freer Gallery has a blue and white porcelain canteen (at left) in exactly the same shape—a rare Ming Chinese piece from the 1400s that experts say was modeled after the brass pilgrim flask. The porcelain canteen has rings to carry a strap, and is decorated with waves, arabesques, flowers, leaves and geometric designs.



27. Esin Atil et al, *Islamic Metalwork in the Freer Gallery of Art*, (Washington DC: Smithsonian Institution, 1985), pp. 124-135.

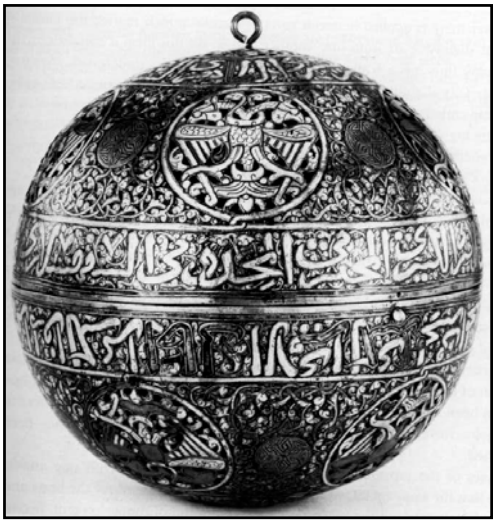
28. Atil, p. 133.

■ Candlesticks, from "Islamic" Metal Shops to Chinese Pottery

Another example of traveling styles and forms across cultural boundaries are these candlesticks. Like silk during an earlier period, porcelain was a Chinese monopoly. Chinese workshops turned out products especially for export to the huge, wealthy Muslim market, aided by the regular trade contact on maritime and overland routes. Here, typical Muslim metalwork candlesticks—a household necessity—were fabricated from brass sheets and decorated in many ways. The exact, unusual nine-sided form was picked up by Chinese artisans and transformed into ceramic, with a delightful mixture of Chinese and Islamic ornaments in blue and white. These designs, colors and forms of decoration transformed as they went back and forth between Muslim and Chinese cultural regions, like bees cross-pollinating new species of flowers. Similarities appear in rug designs, ceramics, miniature paintings, book bindings and textiles. It is important to remember that not just goods, but also artisans and their families traveled between cultures, cities and well-paying jobs.

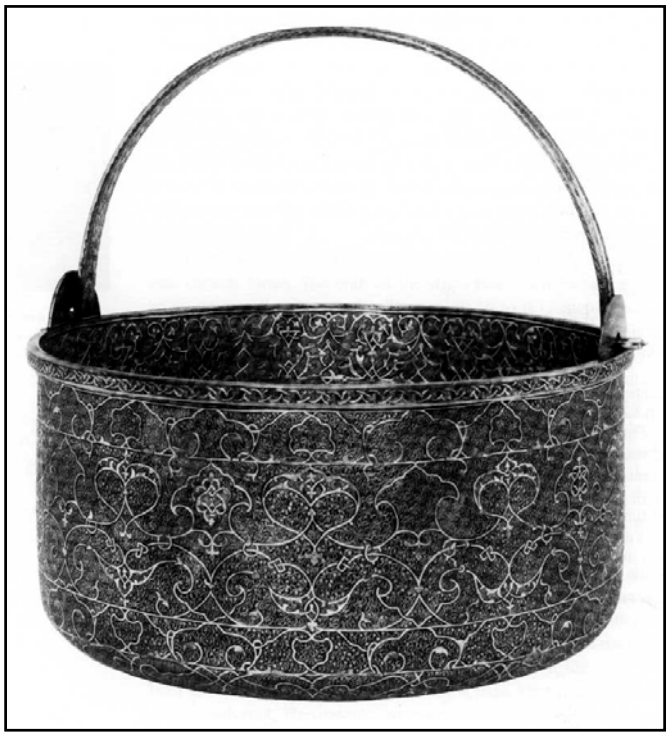
■ Hand-Warmer for Export to Europe, 15th-Century Damascus in Brass, Silver and Gold[29]

This idea seems to have come from 7th- to 9th-century metalworkers in China, where small, spherical firepots were made in silver and hung by chains from the ceiling. Muslim artisans began to make inlaid brass, silver and gold incense burners. Merchants started an export business in these burners, which were used as hand warmers in Europe's cold climate. The pierced body of the inlaid ball opened with a hinge. Inside was a brass pan to hold the hot coals. It rotated in any direction on a gimbal, to prevent the pan from tipping over when it was rolled across the floor. When used for incense, this would allow it to fill the whole room with scent. When used as a hand-warmer, we can imagine how it could be rolled from one person to another across the room. By the 1700s, metalworkers in Venice had begun to imitate these globes, and some Muslim artists, like Zayn al-Din and Mahmud al-Kurdi, even emigrated to Venice where they taught their skills to local craftspersons.[30] Venetian metalworkers who used Muslim techniques and styles called themselves *al-Azzimina*, after the Arabic word for non-Arabs, *al-ajam*.[31] Side-by-side with Muslims, or in competing shops, they made many trays, bowls, buckets, boxes, hand-warmers, vases and large pitchers called ewers (originally designed for Muslims to wash for prayer).



29. Rachel Ward, *Islamic Metalwork*, (London: Thames & Hudson, 1993), p. 115.
30. Atil, p. 173.
31. Atil, p. 178.

■ Brass and Silver Inlaid Bucket with Handle, Gilded Inside, Made in Venice by Muslim Artisan, mid-1500s.[32]



Imagine fetching a pail of water with this fancy piece of metalwork. In the finest households, the servants would have drawn the mistress or master's bath with something like this. It is another example of influence on Renaissance Italy from Muslim artisans, both in style of decoration and in technique. The bucket is made of spun brass. The entire bucket, inside and out, is covered with delicate arabesque patterns, done in four ways:

1. a background texture and design is made by hammering with small steel punches.
2. grooves were cut in the brass and then silver wire and cut sheets were pounded in to make the inlay.
3. strips decorated with geometric engraved designs were soldered onto the bucket handle and rim.
4. gold was applied by gilding, similar to gold plating.

The last step was to highlight the design by rubbing a black organic compound into the indented places and polishing the bucket. This made the design stand out.

Experts think this work is so fine and so typically "Islamic" that it must be the work of the most highly skilled of Muslim artisans working in Venice. Only about six examples of such buckets exist. This one is in the Smithsonian's Freer Gallery of Art, Washington, D.C.

■ Mamluk Brass and Tin Lunch Box

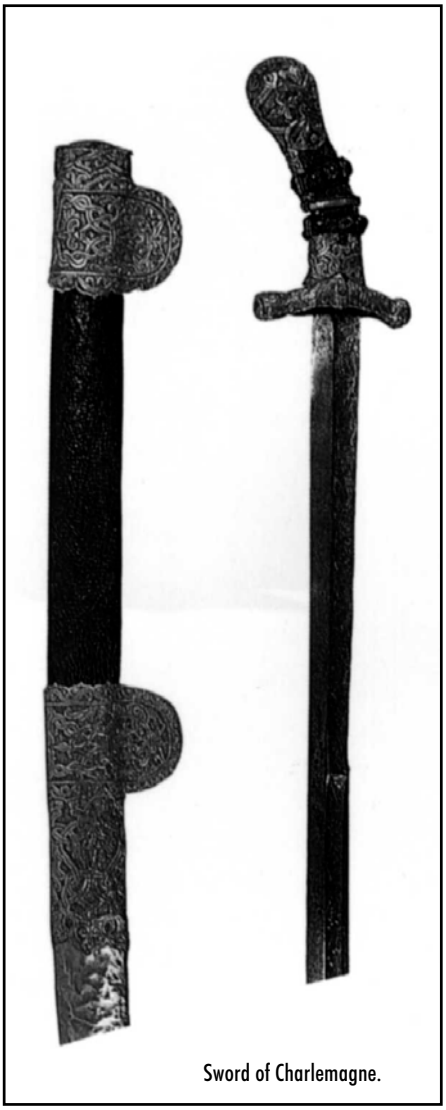
This lunch box from 15th-century Damascus is complete with three separate compartments and a lid that could be turned over to use as a bowl. It has holes to hold a strap or chain that held the parts together, and might even be locked. The box was made of brass, but like modern cans for storing food, it was tinned on the inside to prevent the food from reacting with the metal and affecting the taste.

The lunch box was formed by spinning, or pressing the heated metal against a wheel or lathe, a process that required great skill and strength, but gave a very symmetrical result. Each compartment has a lip that fits inside the next. After forming the parts, they were engraved with delicate designs and a popular poem. Engraving means cutting into the metal with sharp steel tools to remove a small amount, but without making holes or making the metal too thin. Notice the combination of sharp geometric and swirling arabesque designs, combined with graceful Arabic script.

Such metalwork, in trays, weapons, and fine household vessels, made popular imports to Europe.

32. Atil, pp. 176-180.

■ Famous Swords, Damascening and Watered Steel Blades



Sword of Charlemagne.

The picture at right shows a ceremonial weapon of great antiquity that belonged to Charlemagne, King of the Franks. It is kept in the Vienna *Schatzkammer* (Treasure Chamber). An expert describes the blade as "single-edged with a slight curve to it, and overlaid with copper decorated with dragons. The grip is set at an angle to the blade, a feature typical of early 9th-century swords from the Near East." The grip, hilt and scabbard are decorated with pierced gold mounts, and the blade is inlaid with copper and gold. It has many other features of swords from Muslim artisans, like the profile of the blade, the angle of its edge, and the use of ray-fish skin on the grip and scabbard. This weapon was presented to Charlemagne by Harun al-Rashid, *Khalifah* (caliph) of Baghdad (785-809 CE).[33]

Another richly decorated sword belonged to the Christian ruler Sancho IV, of Castile, in the late 13th century. It is in every way a fine sword of Muslim origin, probably won during the Reconquista battles in Spain, or it may actually have been ordered from a Spanish Muslim swordsmith's workshop. The hilt of the sword is bronze, engraved with Islamic inscriptions of piety in Kufic Arabic script. The steel blade is also decorated in gold inlay with Arabic writing engraved into the steel. On the grip are enameled panels showing the arms of Castile and Leon, perhaps added after it came into Sancho's possession. Such swords won in battle became heirlooms, often associated with stories and historical events, like that of Charlemagne.

The famous legendary epic of the Spaniards, *El Cid*, tells how the champion knight captured his famous sword, named *Tizona*, from a Moorish (or Spanish Muslim) knight. The epic tells how the heroic Cid, before his death, had ordered his body to be embalmed and set upon his famous Arabian horse, sword in hand, to be sent into battle one more time. The epic states:

> *"Saddle next my Babieça, Arm him well as for the fight;*
> *On his back then tie my body, in my well-known armour dight.*
> *In my right hand place Tizona; lead me forth into the war.*
> *Bear my standard fast behind me, as it was my wont of yore."*[34]

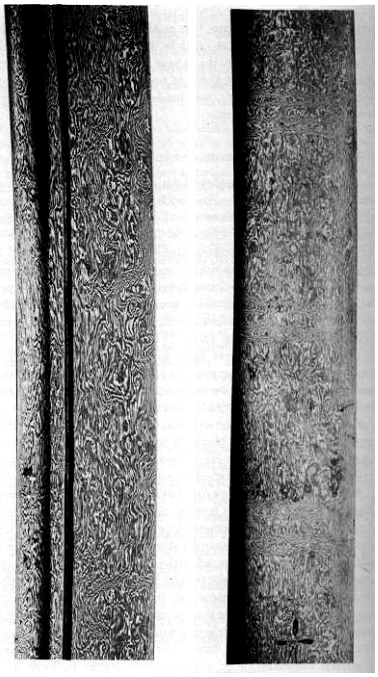
A final chapter of the legend surrounding the Cid was that his corpse was kept for ten years after his death in a church in Castile, seated in a chair. A visitor to the church remembered the Cid's boast that no one ever dared touch his beard while he lived, and so tried to touch the dead Cid's beard. The epic states:

> *"Ere the beard his fingers touched,*
> *lo! the silent man of death,*
> *Grasped the hilt and drew Tizona,*
> *full a span from out the sheath."*[35]

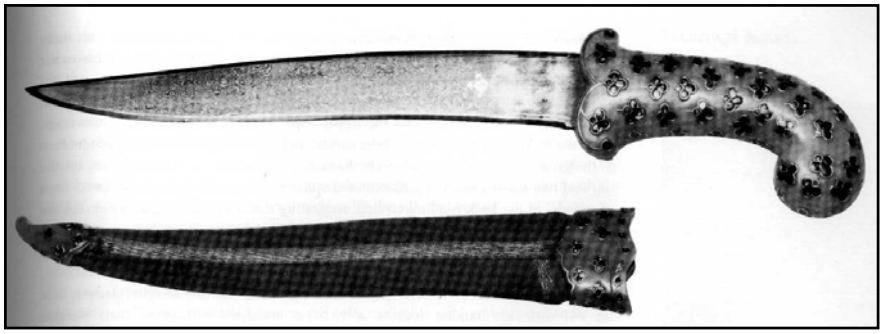
33. Michael D. Coe, et al, ***Swords and Hilt Weapons***, (New York: Barnes & Noble, 1993), pp. 35-36.

34. H.A. Guerber, ***Legends and Myths of the Middle Ages***, (New York: Dover Publications, 1993. [Dover reprint of G.G. Harrap edition, 1909]), p. 366.


Sword of Sancho.


Pattern of watered steel, showing the two types of crystals in the finished blade.

Swords from Muslim lands were important more for their qualities, however, than for any legends attached to the knights who used them. Perhaps the Cid's Tizona was a "Damascus steel" blade produced at Toledo, Spain, which is still famous for its cutlery today. If so, it was hard enough to hold a sharp edge, but still flexible enough not to break. They were unlike the ordinary forged steel blades found in other European countries. Damascus steel, which was a name for such blades from various Muslim lands, were also called "watered steel," because the blade showed a wavy pattern of dark and light material mixed together. The secret to making steel is getting the right amount of carbon into the iron (carbonizing) so that it is not soft like wrought iron, but not so brittle as cast iron, either. Early Muslim writers like al-Kindi and al-Razi, al-Biruni and Jabir Ibn Hayyan wrote about the process of making Damascus steel: wrought iron was mixed in a crucible with a recipe of mineral and vegetable matter and heated with bellows until it melted and whirled. The skilled blacksmith knew exactly when it had reached the right point. Finally, the crucible was left to cool, and steel "eggs" were left. From the steel eggs, which were exported, tools, blades and other things were made. The mixing of crystals of cementite (an iron carbide) and pearlite (iron mixed with iron carbide) resulted in a bi-colored metal. When it was heated and worked further, the swirled pattern became stretched to look like wood grain or "watered silk." Damascus steel was unmatched in strength and flexibility, and ability to hold a sharp edge.


Watered steel blade with jade handle, rubies and gold decoration, from 17th-century India.

35. Guerber, p. 367.

The tradition of making the steel probably originated in India. Persians also had perfected the secret of making it. In Islamic times, steel manufacture spread to Damascus, Cairo and Toledo, among other Muslim centers. Because the blades of swords were often changed, not many early swords exist from Muslim regions. Unlike other cultures, none have been found in tombs, since Muslims do not bury artifacts with their dead. Many blades of watered steel exist in museums today, but they date mostly from 17th- or 18th-century Mughal India or Safavid Persia.

A fine example of one, with a jeweled handle, is shown above. European scientists, keen to learn the secret of Damascus steel, experimented for over 150 years. To the present day, experts are not certain exactly how the craftsmen achieved the fine patterns in watered steel. In experimenting, however, with Damascus steel, Western scientists came upon many discoveries about steel-making that led to the invention of the Bessemer and Siemens steel-forging process for mass production.

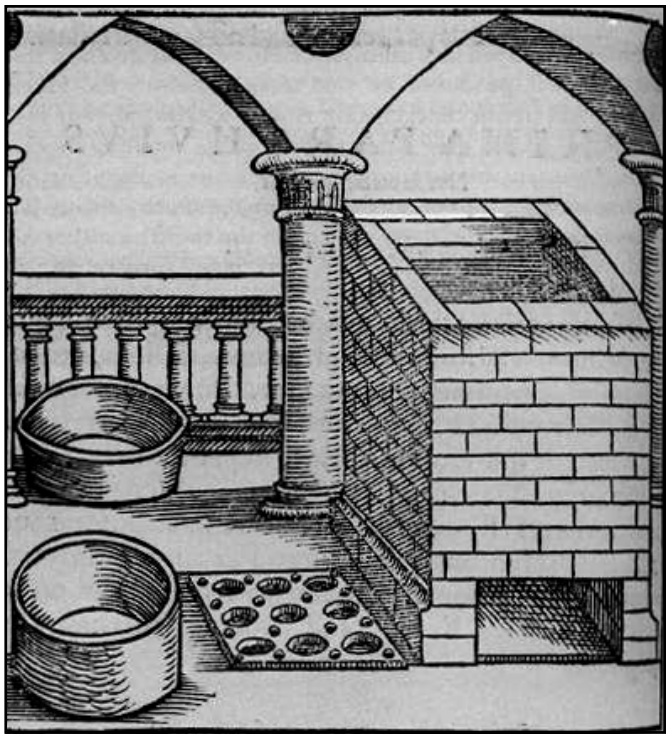
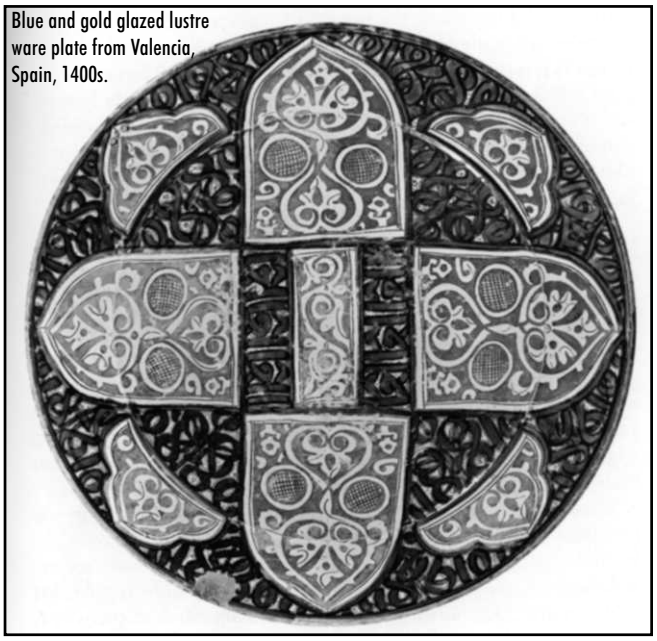


Illustration of a steel-making crucible furnace from De Res Metallica, the first European book printed about metallurgy, in the 1500s, probably based on the 13th-century Arabic manuscript of Jabir.

2. Ceramic Tiles and Dishes from Spain, Turkey, India and Central Asia


Blue and gold glazed lustre ware plate from Valencia, Spain, 1400s.

Tile offers the most beautiful way to decorate surfaces with bright colors. Tile is not damaged by water or bleached by the sun. Unless they are broken, tiles last almost forever. The basic technique and use of tile goes back to Babylonian times. Artisans from Asian cultures—China, Central Asia, Persia and the Middle East—made many advances during the centuries of Muslim civilization's development. Tiles can be so brilliant that Muslim geographer Yaqut wrote in the 1200s that he could see the blue-tiled domes of Merv from a day's journey away.[36]

Tiles are made of molded, baked ceramic slabs, either in red or white clays. Muslim artisans, trying to imitate translucent Chinese porcelain, developed a hard white ceramic called stone-paste that became a popular substitute. Stone-paste was a mixture of finely ground quartz pebbles, white clay and a kind of ground glass called "frit." It was similar to a clay used in ancient Egypt to make artificial faience gems, but it had disappeared until Muslim potters re-invented it in the 1200s, and passed it on to Europe. Today's stoneware uses a similar formula.

Glazing puts a fine layer of melted glass onto the ceramic that is both colorful and permanent. Tiles are glazed using compounds made from metal ores like oxides of lead, iron, tin and "salts" of other metals. *Flux*—another chemical substance—was added to lower the melting point of the glaze. The most carefully guarded secrets of glazing are:

- the minerals that give certain colors (they don't show the color until they have been fired)
- the methods of applying the colors (on bare ceramic, over white or under clear glazes)
- the time and temperature at which they are fired in the kiln (oven)


Cuerda seca tile from India, 1600s.

One of the most difficult glazing methods was called **Lustre**, in which metallic gold was painted on and fired, often with other colors. In 1558, an Italian potter named Piccolpasso was visiting the pottery workshops at Kashan, Persia, to learn first-hand. He said, *"Many make the lustre kilns on the floor of houses that are locked and under close guard, for they look to the manner of making the kiln as an important secret and say that in this consists the whole art…the art is treacherous for oft times out of one hundred pieces of ware tried in the fire, scarce six are good."* Abul Qasim, a Muslim scholar writing on luster manufacture for the Mongol court in 1301 writes, *"that which has been evenly fired reflects like red gold and shines like the light of the sun."*[37]

36. Venetia Porter, *Islamic Tiles*, (New York: Interlink Books, 1995), p. 64.
37. Both primary source quotations from Porter, p. 16.

Another glazing technique first invented by Muslim artisans in Central Asia is best known by its Spanish name of *cuerda seca* [meaning "dry cord"]. At Samarkand around the time of Timur, tile mosaics called *zillij* were made with fancy cut pieces of tile fitted together to make designs. The Asian artisans found a quicker way to do it. The glazier used an oily, black substance mixed with powdered metal called manganese to draw the design on the tile. The glaze would not run over this "dry" line, so it formed boundaries between different bright colors of glaze—similar to a mosaic. This technique traveled to India, Turkey, the Middle East, and Spain during the 1400s and 1500s, where it was copied by Spanish and Italian artisans. It gave the artist freedom to draw detailed pictures in many colors. Muslim artisans transferred this technique to Spanish and Italian potteries. Modern collectors prize Spanish tiles and colorful Italian ceramics called Majolica, which are still made today.

In the Ottoman period, Iznik, Turkey became an important center for ceramics of all kinds. White ceramic was decorated with beautiful designs of trees, swirls and flowers—especially the tulips and carnations that became a craze in Europe. These designs combined influence from Chinese and Persian sources with Turkish tastes and skill. At first, Turkish workshops produced tiles using pure white tin or lead glazes combined with bright cobalt blue. Designs were painted on, in lighter and darker shades. To glaze many tiles at once, Turkish potters used a **stencil** to reproduce identical patterns. Both the glaze chemistry—white and cobalt blue—and other qualities of the Turkish tiles influenced another important European manufacturing center. Just as Turkish tulip bulbs brought fame and wealth to Holland, the techniques for making blue-and-white hand painted and stenciled ceramics established an international reputation for Holland's Delft tiles in the 1700s and 1800s. They are still exported today.

Stenciled design in blue and white, showing Chinese lotus flowers and "Islamic" arabesques.

Turkish artisans innovated beyond blue and white during the 1500s. New chemical compounds were discovered that produced brilliant red, golden yellow, apple and emerald greens, turquoise and pale lavender. Designs done in **polychrome** (many colors) at Turkish workshops were spectacular. The Ottoman sultans built *masjids* and palaces like the Topkapi Serai in Istanbul that featured whole rooms lined with tile panels. The first Europeans to see this tile-work were diplomats at palace audiences. They wrote descriptions in their travel diaries, and reported directly to kings and potentates of Europe. Wanting to display the best of everything, they would have ordered some of the work, or hinted through diplomatic channels that this would make a desired royal gift. Royal gifts, of course, were also a method for introducing new trade goods for export. Members of the court and other wealthy Turks hosted visiting diplomats and merchants, giving information on where to purchase the coveted ceramics.

Once these goods were exported to Europe, growing scientific knowledge over the next centuries helped artisans and scientists discover the trade secrets that enabled them to copy the technology. Sometimes it took decades of experimentation to figure it out. By the 18th century, for example, European scientists had unlocked the centuries-old secret of Chinese porcelain, or "bone China" and experimented with its manufacture. Through such "industrial espionage" and imitation, European manufacturing skills and styles of design developed. Copied first in handicraft shops, later industrial processes allowed them to be mass-produced. During the 18th and 19th centuries, these cheap imported substitutes for traditional Muslim crafts flooded into Muslim lands. Then, many of these centuries-old crafts almost died out.

3. Glassware


Enameled beaker.

Blowing, molding and cutting glass were among the techniques used to produce fine utensils for wealthy patrons in Muslim lands. Artistic glass products from Muslim culture included lamps for *masjids* (mosques) and homes, and containers for cosmetics and food. Syria was famous for the technique of enameling glass. Arabesque designs swirl around the delicate shape of this blown drinking glass. It might have been used for tea, or for *sharbat*, an iced, syrupy fruit drink that gives us the word *sherbet*. The finished glass form was painted with different colors of glass, or even gold and silver compounds. Like glazed ceramic, it was then reheated to melt the design permanently onto the glass. Some of the finest examples of enameled glass from Syria, Egypt and Persia are lamps for homes and *masjids* (mosques), plates and bottles.

Since Roman times, Syria had been a center for production of fine glassware. Persia, too, had its centers, from Sassanian times, with traditions reaching back to Mesopotamian culture. Although Egypt had also produced glass from early times, Syria was the most famous manufacturing center in the Muslim lands. In Europe, Venice became an important Renaissance glass-making center. How did they acquire the technology that had been a centuries-old Syrian tradition? Scientific historians Ahmed Hassan and Donald Hill cited a treaty from the Crusades period that provides very solid evidence of cross-cultural technology transfer: "*...a treaty for the transfer of technology was drawn up in June AD 1277, between Bohemund VII, titular prince of Antioch, and the Doge of Venice. It was through this treaty that the secrets of Syrian glass-making were brought to Venice, everything necessary being imported directly from Syria—raw materials as well as the expertise of Syrian-Arab craftsmen. Once it had learnt them, Venice guarded the secrets of technology with great care, monopolizing European glass manufacture until the techniques became known in seventeenth-century France.*"[38]


Furnace for making artificial rubies.

The two main ingredients of glass are *silica* (sand), and in Arabic language, *al-qali*, which gives us the English word *alkali*. It was described by al-Razi in the 10th century. Concentrated *al-qali* salt was a major Syrian export, mentioned in the early Italian Renaissance technical manual, *Pirotechnia*, by Vannoccio Biringuccio. An innovation mentioned by the chemist Jabir ibn Hayyan and other Arabic sources was adding manganese dioxide to glass to make it clear and colorless. Manuscripts on alchemy contain recipes for making stained glass in black, sapphire blue, red, yellow and green by adding other metallic oxides to the glass. In Persia and Syria, fine vases were made of deeply stained glass, molded with designs or cut with diamond or emery wheels to make it sparkle and catch the light. These artworks were highly prized in Europe. Stained glass designs were set in stucco to decorate Middle Eastern homes and buildings. The transfer to Spain of this technique may be the origin of stained glass windows in geometric patterns, which European artisans set into lead frames to make the glorious rose windows of cathedrals. In addition to the glass technology, stained glass windows also borrowed elements of Islamic geometric and arabesque design.

Glass technology also led to new developments in the art of jewelry making. Artificial gems resembling rubies, sapphires, emeralds and cat's eyes were made in the Muslim lands to allow the less-than-wealthy a chance to wear fine jewelry. The illustration shows a furnace for making artificial rubies and sapphires from a 16th-century Arabic manuscript.

38. Ahmad Y. al-Hassan and Donald Hill, *Islamic Technology*, (Cambridge: Cambridge University Press/Unesco), 1986), p. 153.

4. *Pietre Dure* Gem Inlay from the Medici or the Mughal?

Bird panels in precious stone inlay, from the back wall of the Mughal throne room, Delhi. The left panel shows a hoopoe on a fruit tree.

The illustration shows the wall behind the throne where Shah Jahan, 17th-century ruler of India, sat in state. On a background of white marble are pictures of birds, flowers and trees. The designs are made with inlaid pieces of semi-precious, colored stones, a technique called *pietre dure*, meaning "hard stone" in Italian. The *pietre dure* artist made pictures entirely from thin slices of precious stones in various colors, fitted precisely together like pieces of a puzzle, then polished so that no seams showed between the stones. What made the pictures so interesting was that the artist carefully selected stones of different colors, and used the natural markings, veins and variations in the stone to represent the natural texture of a leaf, a bird's feather or a mountain. Using, of course, only hand tools, the artist had to know the characteristics of various gemstones, like agate, lapis lazuli, jade, mother of pearl, and others. Many slices might be painstakingly cut and then rejected until a slice was found with just the right texture and coloring. Then, the hard stone was carefully cut to fit into the design. *Pietre dure* work was used for panels set into walls, on tomb coverings and fine furniture like chests of rare woods. These vari-colored gemstones came from remote sites in Asia, Africa, and Europe. Petrified wood from the Americas was even included in some. The work required large quantities of these rare materials, much of which might be wasted. The intricate skills of the artisan added even more value. All of these features added up to an extravagant display of luxury that spoke of the wealth and cosmopolitan qualities of the patron, in addition to its beauty that showed off his or her fine tastes. As a final touch, gem-stones were often believed to have spiritual or even magical qualities

Pietre dure is an example of styles and techniques that traveled from one culture to another, sometimes more than once. Indian and Italian art historians debate about the origins of *pietre dure*, because fine examples from around the same time are found in both cultures. Mosaics and inlay work in colored stone are found in earlier Indian architecture, both in floors and wall decorations, from the 15th century on. These are mostly geometric in design. Italian *pietre dure*, however, involved a picture—often of naturalistic plant and animal themes—that incorporated use of very hard gemstones to make the entire design. The Italian workshops made the designs look like paintings. It originated at the private workshops of the famous Italian Medici family, with some inlaid tabletops done for the family palace. The technique drew attention in elite circles when it was used to make a portrait of Cosimo I de Medici in about 1598. *"And so we have contrived a new way to join stones, not in the old mosaic way, but with artful cunning, so that effigies and portraits of persons are done in natural colors, even in the various parts of the face…"* wrote the Medici Grand Duke Ferdinand I de Medici as he sent Pope Clement VIII a similar *pietre dure* portrait made three years after the original.[39] Later, the technique was used for delicate works like the sunflower panel, from the 1600s, shown on the next page.

Whether the artisans of Florence originally saw Indian or other stone inlay and came up with their own refined variation is not clear. By the early 1600s, however, it is known that Italian *pietre dure* panels were being exported. Around the same time, use of hard stone inlays in flower and bird patterns begin to appear in Mughal (Muslim Indian) architecture. It is known that the Medici sent buyers to India to purchase precious stones, and that Italian lapidaries [gem artisans] named Verano, Austin de Bordeaux and Bronzoni were employed at the Mughal court. In the Taj Mahal, built by the Mughal ruler Shah Jahan, the tombs of Mumtaz Mahal and her husband are surrounded by a lacy marble railing. The tombs, the railing and the walls are decorated with intricate *pietre dure* work. The technique may have been borrowed from Italy and may have originated in India, or it may be the product of both cultures. The style is originally Indian, though, and adds to the magic of one of the most beautiful buildings in the world. Each of the two cultures expressed different styles and tastes, resulting in a different effect produced by the work.

39. Dalu Jones, *A Mirror of Princes: The Mughals and the Medici*, (Bombay: Marg Publications, 1987), p. 126.

Notice how the parts of the sunflower take all of their texture from the various precious stones combined in this fine example of *pietre dure*.

The premier style-setters of the Renaissance period were the courts of rulers. In the art productions with which they decorated their courts, their capitals and their persons, the power of the leaders and the wealth of the state was projected for all to see. The pride of a culture and of a place was put on display as an obligation of the ruler. As travel and communication expanded—across the Eastern Hemisphere and then across the globe—the display of wealth, of refined tastes and of state power became an international affair. Apart from the competition among rulers, there was also a feeling of kinship, as members of an exclusive group who often indulged in the idea that there was something even divine about them—as rulers entrusted with leadership by God.

As their work became well known, artisans also became international figures, moving from capital to capital at the request of ruling circles. Among the most famous of these were the highly skilled artisans who designed and decorated the royal palaces and public buildings that were the grandest statements of the rulers' power and wealth. There is perhaps no more culture-specific artistic expression of a civilization than architecture—and none more visible to travelers. Architecture creates a backdrop for the ruler's public ceremonies like no other. Into these lavish buildings, wealthy rulers poured the best of native products and rare materials imported from faraway lands. What could be a more amazing display of wealth and beauty than a building set with precious and semi-precious gems?

SUMMARIZING IDEAS

SEGMENT 3: SCIENCE AND TECHNOLOGY

Before the advent of the secular modern era, religion was a major factor in the consciousness of people throughout European society and elsewhere. People in many regions centered their daily life around activities at their house of worship, whether church, *masjid* (mosque), synagogue or temple. This was where one found a spouse, mingled with family and friends, and participated in ceremonies commemorating births, marriages, and death. Europeans centered their lives around the church, marking time with holy days and feasts that celebrated the works of saints. Church leaders held positions of great authority and at times accumulated tremendous powers beyond the church.

In today's more secular world it may be difficult for us to relate to a life style which was wholly centered on religious faith. Yet religion also entered into the economic, political and intellectual realms of a community. Occasionally this caused conflicts. For instance, when European scientists proposed a new way of looking at the cosmos by considering the heliocentric model (with the sun in the center rather than the earth) they came up against church leaders who felt that some of the basic beliefs of Christianity were being challenged.

SCIENCE AND FAITH

While there were some similar problems between faith and science within Muslim culture, there was not an effect similar to the conflict experienced by Galileo, for example. There is no central religious institution or official clergy in Islam, either. Muslim scientists worked within an atmosphere of support for learning and a spirit reflected in the *Qur'an* and the *hadith* (sayings of the Prophet Muhammad) that offered strong encouragement to scientific exploration. Muslim scientists and scholars could refer to verses of the *Qur'an* stating that reflection upon and study of the natural world is one way to appreciate the gifts that God bestowed upon humankind. The *Qur'an* points to natural phenomena such as wind, rain, and the abundance of plant life as signs of God's mercy and provisions for this life. Although many Muslim scientists defended their work from a religious point of view, scientific work was a respected part of intellectual life in Muslim society. In general, Muslim scientists worked under fewer restrictions than their medieval counterparts in Europe. Both were concerned, however, with similar questions. In fact, Muslim writings on the links between faith and reason were avidly read by Europe's early scientists after the 12th century.

The spread of Islam eastward to China and westward across Africa brought about tremendous intellectual cross-fertilization. Muslim scholars incorporated the ancient wisdom of the cultures they encountered and blended their ancient learning with a Muslim worldview. The flowering of scholarship that resulted helped plant the seeds of later Renaissance accomplishments. An important factor in this was the mingling of scientific traditions under Muslim rule. Non-Muslims who lived under Islamic rule had many rights specified by law. This enabled Christians, Jews and people of other faiths to play critical roles in the scientific work that began at the *Bayt al-Hikmah* in 8th-century Baghdad and spread across the rest of the *Dar al-Islam* (Muslim territory). A blending of Greek, Indian, Persian, Arab, African and Chinese learning resulted. This knowledge traveled through the cities of the Muslim lands, then entered Europe through the libraries and courts of Spain, Italy and Constantinople.

SUMMARIZING IDEAS: SEGMENT 3

Technologies and Artistic Styles

Manufactured goods and the techniques of making them passed between cultures. Products traveled in both directions along the routes from China to Europe. Metalwork, glassware, textiles, ceramics and jewelry were some of the articles which found an eager market among Europe's nobility and newly wealthy merchant class who gained status by displaying their worldly goods to peers.

Muslim artisans created stunning household items with inlaid bronze, silver and gold. Swords and cutlery made of Damascus- or Toledo-forged steel was prized for holding their sharp edge, for their strength, and for the beauty of their watered pattern. Damascene metal, inlaid and inscribed with designs and *Qur'anic* passages were so valued that they were offered as gifts to eager European royalty. One such sword is said to have been given by the famous *Khalifah* (caliph) Harun al-Rashid, 8th-century ruler of Baghdad, to the equally famous European king, Charlemagne, along with a chess set. Both were so valued that they still exist today. Even lunch boxes and hand warmers were decorated with ornate designs that turned mundane, everyday items into works of art. Metal objects with designs from Muslim culture became so marketable in Europe that even before the Renaissance, Muslim artisans moved to Venice and other European cities, where they kept workshops and taught apprentices, at the gateways to the great markets of Europe. Venice had an entire street of Muslim metal masters' shops.

Chinese porcelain candlesticks show us how technology and artistic styles moved across the Eastern Hemisphere. Popular designs for inlaid metal candleholders with Islamic designs were translated in the Far East into ceramic, using Chinese design touches and technology. The Chinese often produced goods for the Muslim market, just as Syrian and other Muslim artisans produced designs for sale to Italians. Eventually, many designs and techniques were adopted by Europe's artisans.

Porcelain, or "bone china", remained a Chinese monopoly for centuries—much longer than silk and paper technology. The composition of the clay, the method of firing, and its decoration were very sophisticated techniques that remained secret. Technicians outside of China were unable to discover the secrets of porcelain for centuries. In the meantime, Muslim artists imitated porcelain by making a hard white ceramic called "stone paste," which is still sold as "stoneware" today, even after the secret of "bone China" porcelain was acquired by Europeans during the 18th century. Stoneware tiles and other objects glazed in rich colors decorated homes, palaces and *masjids* in Muslim lands. Production of ceramic wall tiles was refined by the Persians, Central Asians and the Chinese. Use of decorative tiles spread across Muslim lands from Asia to Africa and Spain. Today, in places like Samarkand, Jerusalem, Istanbul or Marrakesh, walls, floors, fountains and facades are covered with brilliantly colored tiles that weave together design elements like the Chinese lotus petal and the Islamic arabesque. Tile industries developed in areas of Europe in closest contact with Muslims, especially in Spain and Italy. Later, tiles from Ottoman workshops spread the fashion and the technology further into Europe.

Another example of the developing international style in luxury products is the decorative art of *pietre dure*, which passed between Italy and India. Artisans in both cultures made wall decorations and pictures out of beautifully colored and veined precious stones fitted together in patterns. From palaces of the Medici to the Mughals, these works of art still glow from the walls and floors, and add a delicate beauty to the Taj Mahal. *Pietre dure* art shows how styles and methods traveled from place to place. The artisans themselves were brought to faraway places by wealthy patrons, and the finished works made their way to places far from their origins. On the throne room wall of an Indian palace are *pietre dure* pictures produced in the workshops of Florence!

SUMMARIZING IDEAS: SEGMENT 3

Muslim Scientific Advances in Mathematics and Other Fields

While these great technological advances and exchanges were taking place across the Eastern Hemisphere, many new developments were also being made in the "hard sciences"—mathematics, astronomy, physics, chemistry and medicine. Muslim scholars adopted the Greek belief that mathematics and philosophy laid the foundation of all scientific study. Islamic beliefs and practices also made Muslims particularly interested in mathematics. First, Islamic teachings include the idea of *tawhid*, or unity of God reflected in the diversity of creation. Second, the *Qur'an* contains many references to numbers as signs of God's majesty and the creation of an ordered universe. Third, mathematical precision was critical to accurate calculation of prayer times and dates on the Islamic calendar, and finding the direction of Makkah. Thus, understanding the relationships between time, location and mathematics were important components of practicing Islam.

Muslim scholars drew upon the discoveries made in earlier civilizations like Greece and India. Indian mathematical advances had a strong appeal because they blended eastern philosophy with the study of numbers. From India came the understanding of infinity, the use of symbols to represent a quantity or number, the concept of zero to represent a void, and the use of place values. Scholars working at the *Bayt al Hikmah* in Baghdad enthusiastically explored these concepts and developed them to such as extent that we now refer to the numbers we use today as "Arabic numerals."

Muhammad ibn Musa al-Khwarizmi is among the best known Muslim mathematicians. In the 9th century, he developed the science of *al-jabr* (algebra). Latin translations of his books were influential among European scholars all the way into the medieval and Renaissance era. In 1202 Leonard of Pisa (also known as Fibonacci) introduced the concepts of place values, Arabic Numerals and algebra to Europe after studying al-Khwarizmi's works. Scholars working under Muslim patronage also made impressive developments in trigonometry, geometry, the use of fractions and decimals, and the "arithmetic of the astronomers" by which they improved observations of latitude and longitude and made tremendous contributions to the study of the stars.

Though the Arabs are most often associated with the desert in popular imagination, it is known that the Arabs were also early seafarers. Knowing how to navigate by the stars was critical for survival in both environments. The heavens were a "map" and a guide to the next town, oasis or port. The *Qur'an* also pointed to the stars as a mercy from God, guiding people to seek His bounty by traveling through land and sea. An understanding of the link between time, mathematics and the stars was also critical to the fulfillment of Islamic religious duties. People needed to know when to pray and when to fast. But as Islam spread east to Asia and west through Africa, another religious duty depended upon a thorough understanding of the heavens—the *Hajj*. It would be impossible to perform this duty without knowing how to find the way across seas, mountains and deserts to Makkah.

Muslim scholars studied and corrected the works of famous Greek astronomers like Ptolemy. They enhanced human understanding about the nature of heavenly bodies and the size, location and motion of the planets. Star charts, called *zij* were so accurate that we still use the calendar which was based on the star charts of Ulugh Beg, a 15th-century ruler in Central Asia. Brilliant Muslim and Jewish scholars in al-Andalus (Muslim Spain) improved the accuracy of star charts. Many other Muslim astronomers made significant contributions that influenced European science. Al-Battani, a 9th-century Muslim astronomer, studied the sun's path and explained eclipses. His books on lunar movement were used in Europe into the 18th century. In the 11th century, Al-Biruni accurately plotted the coordinates of cities using longitude and latitude.

European scholars traveled to Spanish centers of scholarship, translated works by scholars like Jabir ibn Aflah and carried them to the libraries of Europe. They became part of the curriculum in Europe's growing universities. The European astronomer Copernicus drew upon works by Jabir, al-Tusi, and other Muslim scientists. Even after the end of Muslim rule in Spain and Sicily, several European kings continued the tradition of royal support for Muslim and Jewish scholarship. Jewish and Muslim scholars worked under the patronage of King Alfonso the Wise, 13th-century Christian ruler of Castile and Roger II of Sicily. Ironically, after casting these groups out of the Iberian peninsula, it was the Spanish who facilitated the transfer of Jewish and Muslim scholarship into Latin Europe.

SUMMARIZING IDEAS: SEGMENT 3

The mystical side of traditional philosophy mingled with Islam in the study of alchemy. The goal in this mixture of scientific study and ancient beliefs was to discover how to change base metals into gold. Alchemists thought that such a discovery would also teach philosophers how to transform humanity—the baser side of humankind would yield to the light of religious truth and faith. Thus, alchemists hoped that they could transmute both the physical realm of the material world and the spiritual realm of man.

Nestorian Christians fled to Baghdad's *Bayt al-Hikmah* to escape the persecution of the Byzantine Empire, and stayed to contribute much to scientific and translation work. Although they obviously never discovered how to change metals such as tin or bronze into gold, in their quest to do the impossible, they made significant discoveries. Their work with changing natural substances led to the science of Chemistry—a word whose root is the Arabic, *al-khemi*. Their work led to advances in the smelting of metals, the creation of laboratory utensils, the creation of pharmaceuticals, and the production of cosmetics. They developed a better understanding of the properties of numerous substances including alcohol, sulfur, lime and glass. But the most significant contributions of these philosopher-scientists were their systematic scientific observations. They kept detailed written records and began the use of the "proof," by which they determined that a scientific discovery was not considered valid unless it could be reproduced. This had a tremendous effect on the development of modern scientific methods. In Europe, perhaps the best known alchemist is Nicolas Flamel, who fused Christian belief with Hinduism, Tantrism, Taoism, Mayan religious beliefs and the cosmic symbolism of Islam. Flamel influenced the works of such great scholars as Roger Bacon, Isaac Newton and Albertus Magnus.

Medicine was a field in which some of the most significant contributions of scientific knowledge to Europe took place. As in other fields of science, Muslim scholars absorbed the medical knowledge of the Greeks, Persians, Indians, and to some extent the Chinese. Using their wisdom as a foundation, physicians working in the Muslim tradition developed a sophisticated body of medical knowledge which was influential as the basis of European medical school curricula until the 17th century.

One aspect of Islamic theology is the belief in a divinely ordained balance in life. This worldview originated in the *Qur'an* and *hadith*, with influences from traditional symbolism, philosophy and the symbolism of numbers and astrology. The Muslim tradition includes the view that there is a relationship among all living things and the rest of creation. Muslim physicians also saw a link between cosmic forces and the well-being of humans. Like other traditional cultures before them, they viewed health as the natural state, and considered illness to be a sign of imbalance. Drawing upon the Greek ideas of harmony and balance, Muslim physicians also believed that a healthy human had the correct combination of the **four humours** (blood, phlegm, yellow bile, black bile), **four natures** (hot, dry, cold, humid) and the **four elements** (earth, water, air, fire). When a person fell ill, the balance was to be restored with food and medication. Muslim physicians also fully understood the effects of psychological stress on the body, so patients were advised to avoid anger and all forms of excess. Music, poetry, garden walks and the sound of running water were elements of the cure.

Muslims considered it a religious duty to maintain good health, since the physical body is a gift and a possession that returns to God. A person was expected to live a life that was productive and beneficial to humanity, sound in body and mind. Islamic practices also emphasized good hygiene. Muslims are required to approach prayer in a physical and spiritual state of purity. For this reason, they performed ablutions (cleansing parts of the body with water) five times per day, and bathed regularly. Scores of books by Muslim doctors detail the links between medical care, the *Qur'an* and *hadith*. Some of these books, called *Tibb al-Nabi* or "Medicine of the Prophet" quoted the example of the Prophet Muhammad in hygiene and health care. These books were among the works in medical school libraries at the great "teaching hospitals" in major Muslim cities.

Scientists and rulers often kept secret their developments in technological skills. Advances in metallurgy, ceramics and glass-making were coveted trade secrets kept from competitors. In medicine, however, new discoveries were gladly shared across the continents. The exchange of medical knowledge between Muslim and Christian cultures was particularly dynamic during the times of plague and during the Crusades. Muslim medical works like the *Canon of Medicine* by Ibn Sina (Avicenna in Latin) and the *Book of Mansur* by al-Razi were basic medical textbooks in Europe over centuries. Particularly after the invention of printing, Europe's best medical schools stocked their libraries with Arab treatises on such things as eye diseases, surgery, small

SUMMARIZING IDEAS: SEGMENT 3

pox, and the circulation of blood. Other books described the pathology of diseases, gave instructions for surgery, illustrated over 200 surgical instruments, described how to relieve pain and calm patients for surgery. They stitched wounds with sutures of animal gut or silk. Pharmacology, or the study of medicinal substances, encouraged the exchange of information and new plants across cultural lines. Natural cures were introduced by Muslim herbalists using plants from all across the hemisphere. In the process, the teachings of great healers of those cultures was transferred. Interestingly, many new food crops and the techniques for growing them were originally introduced for their medicinal benefits. With the advent of the Age of Exploration their benefits reached the new lands.

Through centuries of technology transfer involving the arts, the sciences, trade, agriculture and other aspects of culture, a remarkable exchange of knowledge was achieved among regions of the Eastern Hemisphere. Ideas, discoveries, products, religions and peoples wove their way across the lands, sharing their wealth of knowledge and absorbing what each culture had to offer during this brilliant era of scholarship, trade and travel. Religious faith played an important role in this quest for knowledge within each culture. On the other hand, the difference in religious faith among the various scholars, artists and intellectuals does not seem to have presented a significant barrier to this exchange. The presence of the large Muslim cultural region in the geographic center of the hemisphere, characterized by many unifying features such as language, religion and worldview, helped serve as an important catalyst in this extraordinary exchange.

Science and Technology

SCIENCE AND TECHNOLOGY IN MUSLIM LANDS AND EUROPE

Just a few centuries ago, daily life for people in Europe and most other parts of the world was still centered around their house of worship—the church, the *masjid* (mosque), the synagogue or temple. Here, people found a wife or husband, met with relatives and friends, and took part in ceremonies marking births, marriages, and deaths. During the Renaissance and after, Europeans still marked passing time with the names of holy days and feasts for saints. Church leaders held great authority in society, within the Church and beyond it, using their power over kings and commoners alike.

In today's more secular world, it is hard for some people to imagine how life could have revolved around religious faith. In much the same way that science today seems to play a role in politics, economics and even play, religion has played an important role in forming the cultural life of many societies. Religion has been very important to the development of science and technology in history. In their desire to perfect religious practices, people have been motivated to travel, to investigate the heavens and the world around them, and to develop new technologies. The worldview in each religion has also shaped the way people understand nature and influenced the paths of investigation they choose to follow. What scientists believe shapes their studies and their writings. Their works also take into account the beliefs of their readers. Occasionally, religious thought and scientific ideas have come into conflict. For example, when European scientists stated that the earth revolves around the sun, they came up against church leaders who felt that some of the basic beliefs of Christianity were being challenged. The relationship between science and religion across various cultures shows similarities and differences.

Christian thinker Thomas Aquinas appears in this European painting with Muslim thinker Ibn Rushd, shown here.

Science and Faith

The growth of Muslim culture was associated with developments in many areas of science. There were some conflicts over scientific and religious ideas, but Islamic teachings include many ideas that support scientific work. The *Qur'an* and the *hadith* (sayings of the Prophet Muhammad) encourage investigation of the natural world as one way to appreciate the gifts that God bestowed upon humankind. The *Qur'an* points to natural phenomenon such as wind, rain, and the abundance of plant life as signs of God's mercy. Many Muslim scientific writers defended the importance of their work for Islam, gaining much respect and support in Muslim society. They traveled, wrote, and studied with few restrictions. For one thing, Islam has no central religious authority to challenge and forbid their writings officially. Muslim scientists discussed the philosophy behind their investigations in many books. They were concerned with the relation between faith and reason. These Muslim works were translated and read by Europe's early scientists after the 12th century. The ideas of Muslim philosophers like Ibn Rushd and Ibn Sina were used in important early European scientific writings.

Muslim scholars absorbed scientific knowledge from the many cultures they encountered. They blended this ancient learning with a Muslim worldview. The flowering of scholarship that resulted helped plant the seeds of later Renaissance accomplishments. An important factor in this was the mingling of scientific traditions under Muslim rule. Non-Muslims who lived under Islamic rule had many rights specified by law. Christians, Jews and people of other faiths played critical roles in the scientific work that began at the *Bayt al-Hikmah* in 8th-century Baghdad. A blending of Greek, Indian, Persian, Arab, African and Chinese learning resulted. This knowledge traveled through the cities of the Muslim lands over the centuries that followed. From the 1200s on, Muslim scientific works began to reach Europe through libraries, translations and the courts of some rulers.

Technologies and Artistic Styles

Fine manufactured goods and the techniques of making them passed between cultures through trade and diplomatic gifts. Products traveled in both directions along the routes from China to Europe. Metalwork, glassware, textiles, ceramics and jewelry found eager buyers among Europe's wealthy classes. Beginning with imitations of eastern goods, and sometimes traveling to learn the new ways of working, European artisans gradually developed skills to produce them at home.

Muslim artisans created beautiful objects by combining different metals like bronze, silver and gold. Swords and cutlery made of "Damascus" or "Toledo steel" increased the fame of these cities. Their special way of forging and hardening steel made blades that held a sharp edge, marked with beautiful watered patterns. Damascened metal, decorated with designs and Arabic phrases, were offered as gifts to eager European royalty. The famous European king Charlemagne is supposed to have received such a sword and a carved chess set from the equally famous Muslim ruler Harun al-Rashid. Both items have been treasured to the present

day. Even lunch boxes and hand warmers were decorated with designs that turned everyday items into works of art. Metal objects with Islamic designs were so much in demand in Europe that Muslim artisans migrated to Europe's cities. Venice had an entire street of Muslim metal masters' shops making fine objects for Venetian palaces, and spreading their techniques to Italy's metal artisans.


A mamluk brass and tin lunchbox.

Porcelain, or "china" was another intercultural trade item of great value. The secret for making porcelain was kept by Chinese artisans for centuries—much longer than silk and paper technology. The ingredients of the clay, the method of firing it, and its glaze were very sophisticated techniques. Muslim ceramic artists found an imitation for white porcelain called "stone paste," which is still sold as "stoneware" today. Stoneware tiles and other objects glazed in rich colors decorated homes, palaces and *masjids* in Muslim lands. In Persia, Turkey and Central Asia, techniques for creating decorative tiles were developed further and became important crafts that spread to other Muslim lands. Today, in places like Samarkand, Jerusalem, Istanbul or Marrakesh, walls, floors, fountains and facades are covered with brilliantly colored tiles. Their decorations show designs from many cultures, like the Chinese lotus petal, clouds and the Islamic arabesque. Tile industries developed in areas of Europe that had the closest contact with Muslims—especially in Spain and Italy. Later, tiles from Ottoman workshops spread the fashion and the technology further into Europe.


This Ottoman Turkish tile shows both Islamic and Chinese designs.

Another example of the developing international style in luxury products is the decorative art of *pietre dure*, which passed between Italy and India. Artisans in both cultures made wall decorations and pictures out of beautifully colored and veined precious stones fitted together in patterns. From palaces of the Medici to the Mughals, these works of art still glow from the walls and floors, and add a delicate beauty to the Taj Mahal. *Pietre dure* art shows how styles and methods traveled from place to place. The artisans themselves were brought to faraway places by wealthy patrons, and the finished works made their way to places far from their origins. On the throne room wall of an Indian palace are *pietre dure* pictures made in Florence's workshops!

Muslim Scientific Advances in Mathematics and Other Fields

Exchanges among cultures in the Eastern Hemisphere also encouraged advances in the "hard sciences"—mathematics, astronomy, physics, chemistry and medicine. Muslim scholars adopted the Greek belief that mathematics and philosophy laid the foundation of all scientific study. Islamic beliefs and practices also made Muslims especially interested in mathematics. Islamic teachings stress the idea that the unity of God is reflected in the diversity of creation. The *Qur'an* mentions that one of the signs of God's majesty is the creation of a highly ordered universe. Finally, in order to properly fulfill Islamic duties, Muslims need to accurately calculate prayer times and dates on the Islamic calendar, and find the direction of Makkah from any place where they live or travel.

Muslim scholars drew upon the discoveries made in earlier civilizations like Greece and India. Indian mathematics blended eastern philosophy and astrology with the study of numbers. India contributed the idea of infinity, the use of simple numerical symbols (Hindi numerals), the idea of "zero" to represent "nothing", and the use of place values. Muslim mathematicians explored these ideas over the centuries that followed. Using what are now called "Arabic numerals," they developed complex mathematical expressions with practical applications in law, astronomy, map-making, and even in making beautiful geometric designs.

Muhammad ibn Musa al-Khwarizmi is among the best known Muslim mathematicians. In the 9th century, he developed the science of *al-jabr* (algebra). Umar Khayyam, Thabit Ibn Qurra, Ibn Haytham, Ibn Sina and others made important advances in mathematics. Latin translations of their books influenced European scholars during the late Middle Ages and into the Renaissance. During the Scientific Revolution these works were still being printed and read. In 1202 Leonard of Pisa (also known as Fibonacci) introduced the concepts of place values, Arabic Numerals and algebra to Europe after studying al-Khwarizmi's works. Impressive developments in trigonometry, geometry, fractions and decimals made tremendous contributions to the study of the heavens and the earth's surface.

Though the Arabs are most often associated with the desert in popular imagination, it is known that they were also early seafarers. Knowing how to navigate by the stars was critical for survival in both environments. The heavens were a "map" and a guide to the next town, oasis or port. The *Qur'an* also pointed to the stars as a mercy from God, guiding people to seek His bounty by traveling through land and sea. An understanding of the link between time, mathematics and the stars was also critical to the fulfillment of Islamic religious duties. People needed to know when to pray and when to fast, and how to reach Makkah across seas, mountains and deserts to perform the *Hajj*.

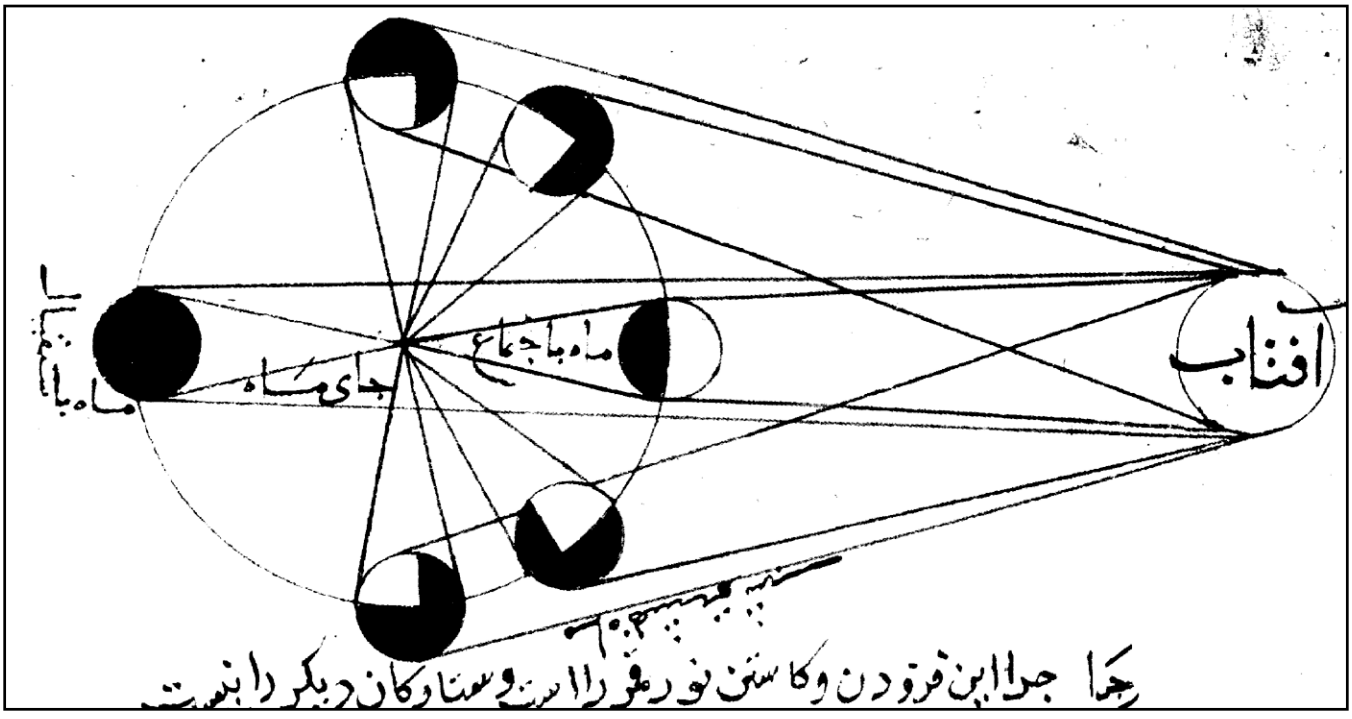
Muslim scholars studied and corrected the works of famous Greek astronomers and geographers like Ptolemy. They enhanced knowledge of heavenly bodies and the size, location and motion of the planets. Scholars like Ulugh Beg, son of Tamerlane, who preferred the observatory to the throne room, made star charts so accurate that we still use the calendar that was based on his maps of the heavens. Jewish and Muslim scholars in *al-Andalus* (Muslim Spain) also improved the knowledge of astronomy. Copernicus himself is known to have owned a

work by the Andalusian Muslim astronomer Jabir ibn Aflah. Jabir had questioned Ptolemy's calculations based on an earth-centered universe. Many other Muslim astronomers made significant contributions that influenced European science. Al-Battani, a 9th-century Muslim astronomer, studied the sun's path and explained eclipses. His books on lunar movement were used in Europe into the 18th century. In the 11th century, Al-Biruni accurately plotted the coordinates of cities using longitude and latitude, and studied the phases of the moon. He wrote a whole book on the mathematics of light and shadows.

European scholars traveled to Spanish centers of scholarship, translated hundreds of works into Latin, and carried them to the libraries of Europe. These sources became part of the curriculum in Europe's growing universities. Even after the end of Muslim rule in Spain and Sicily, several European kings continued the tradition of royal support for Muslim and Jewish scholarship. Jewish and Muslim scholars worked under the patronage King Alfonso the Wise, 13th-century Christian ruler of Castile, and Roger II of Sicily. Ironically, after expelling Jews and Muslims from their lands, these Spanish rulers helped to bring Jewish and Muslim scholarship into Latin Europe.

The mystical side of traditional philosophy combined with Islamic ideas in the study of alchemy. The impossible goal of alchemy was to discover how to change ordinary metals into gold. Alchemists also wanted to teach philosophers how to transform humanity through this mysterious area of knowledge. Alchemists hoped that they could transmute both the physical realm of the material world and the spiritual realm of man. Although they never discovered how to change metals such as tin or bronze into gold, they did make important discoveries. Their work with trying to change natural substances led to the science of chemistry (from the Arabic word *al-khemi*). They discovered the different states of matter, and how substances reacted to changes in temperature. They invented basic laboratory utensils and described

Al-Biruni's diagram of lunar eclipses.



processes like filtration, distillation and sublimation. Their work led to advances in the smelting of metals, the development of medicines, and the production of cosmetics and other useful products. They described the properties or characteristics of many substances, like alcohol, sulfur, lime and many chemical compounds. The most significant contributions of these philosopher-scientists were their systematic scientific observations. They kept detailed written records and believed that a scientific discovery was not considered valid unless it could be reproduced. This had a tremendous effect on the development of modern scientific methods. The alchemists influenced the work of such great scholars as Roger Bacon, Isaac Newton and Albertus Magnus.

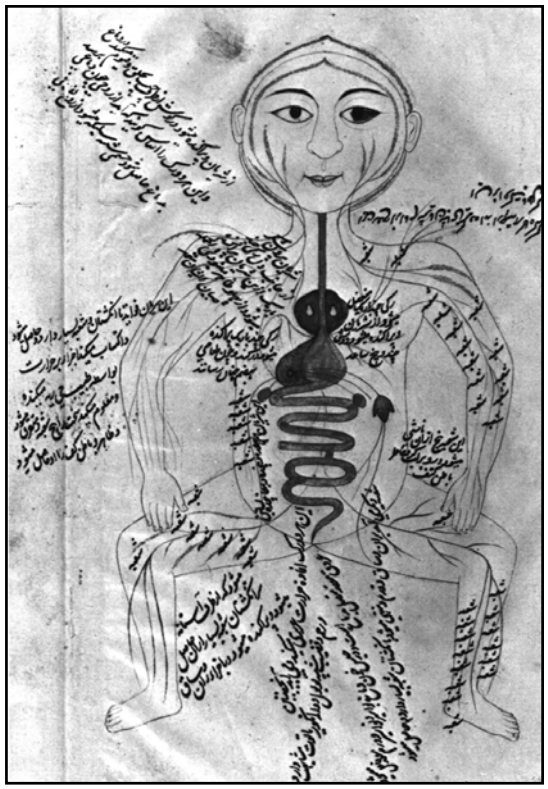
Some of the most significant Muslim contributions of scientific knowledge to Europe were in medicine. As in other sciences, Muslim scholars combined knowledge of many cultures with which they came in contact. Over several centuries, physicians working in the Muslim lands developed much medical knowledge. Hospitals, pharmacies, surgical techniques, diagnosis and prevention were among the areas in which Muslim doctors contributed to human health. Muslim works of medicine formed the basis of European studies in medical schools until the 17th century.

Islamic teachings emphasize achieving a balance in life. This worldview originated in the *Qur'an* and *hadith*, and it combined with ideas from other sources and cultural traditions. Islamic teachings also include the view that there is a relationship among all living things and the rest of creation. Muslim physicians shared with many other medical traditions the concept that being healthy is the normal, natural state of a person. Illness was seen as a sign of imbalance in the normal state of the body. Drawing upon ancient Greek medical ideas, Muslim physicians also believed that a healthy human had the correct combination of *the four humours* (blood, phlegm, yellow bile, black bile), *the four natures* (hot, dry, cold, humid) and *the four elements* (earth, water, air, fire). Illness could be cured by restoring this balance with certain foods and medications. Muslim physicians also fully understood the effects of psychological stress on the body. Patients were advised to avoid anger and all forms of excess. Music, poetry, garden walks and the sound of running water were elements of the cure.

Muslims considered it a religious duty to maintain good health, believing that the physical body is a gift that returns to God. Muslims should live productive lives that benefit others, and try to remain healthy in body and mind. Islamic practices also emphasized good hygiene. Muslims are required to cleanse the body with water before prayer, wear clean clothes, and to bathe regularly. Links between medical care, the *Qur'an* and the *hadith* were popular topics for books. *Tibb al-Nabi* or "Medicine of the Prophet" quoted the example of the Prophet Muhammad in hygiene and health care. These books were among the many works from Muslim and other cultures that were stored in medical school libraries at the great "teaching hospitals" in major Muslim cities.

Scientists and rulers often kept secret their developments in technological skills. Advances in metallurgy, ceramics and glass-making were coveted trade secrets kept from competitors. In medicine, however, new discoveries were gladly shared across the continents. The exchange of medical knowledge between Muslim and Christian cultures was particularly dynamic during the times of plague and during the Crusades. Muslim medical works like the *Canon of*

Medicine by Ibn Sina (Avicenna in Latin) and the *Book of Mansur* by al-Razi were basic medical textbooks in Europe over centuries. Especially after the invention of printing, Europe's best medical schools stocked their libraries with Muslim medical books on topics like eye diseases, surgery, small pox, and the circulation of blood. Others described various diseases, gave instructions for surgery and described over 200 surgical instruments. These books showed how to relieve pain and calm patients during and after surgery. Muslim surgeons stitched wounds using animal gut or silk.



Persian book on anatomy shows blood circulation.

Pharmacology, or the study of medicines and medicinal plants, encouraged the exchange of information and helped introduce new plants among cultures. Natural cures and therapies were introduced in books of herbs and medicines, using plants from all across the Eastern Hemisphere. In the process, the knowledge of great doctors from those cultures was transferred. Interestingly, many new food crops and the techniques for growing them were originally introduced for medicinal uses. Sugar, for example, was originally used as a medicine, then as a syrup in which to put bad-tasting medicines. Later, many new crops improved the health of people in new lands by giving them better nutrition.

Through many centuries, skills and knowledge from the arts, the sciences, trade, agriculture and other fields moved from East to West. Crops and beneficial plants native to tropical regions were introduced into the temperate zones. New ways of using many substances like metals and minerals enriched the lives and raised the standards of living of people in many regions. Ideas, discoveries, products, and religion, as well as curious and skilled individuals wove their way across the lands, sharing their wealth of knowledge and absorbing what each culture had to offer. Religious faith played an important role in this quest for knowledge and benefits. Differences in religious faith among the scholars, artists and intellectuals do not seem to have prevented these exchanges across cultures. Even language differences did not hinder the exchange, as translators appeared wherever their services were needed. The presence of the large Muslim cultural region in the geographic center of the hemisphere, having many unifying features such as language, religion and worldview, was an important catalyst in this hemispheric exchange.

MAP ACTIVITY

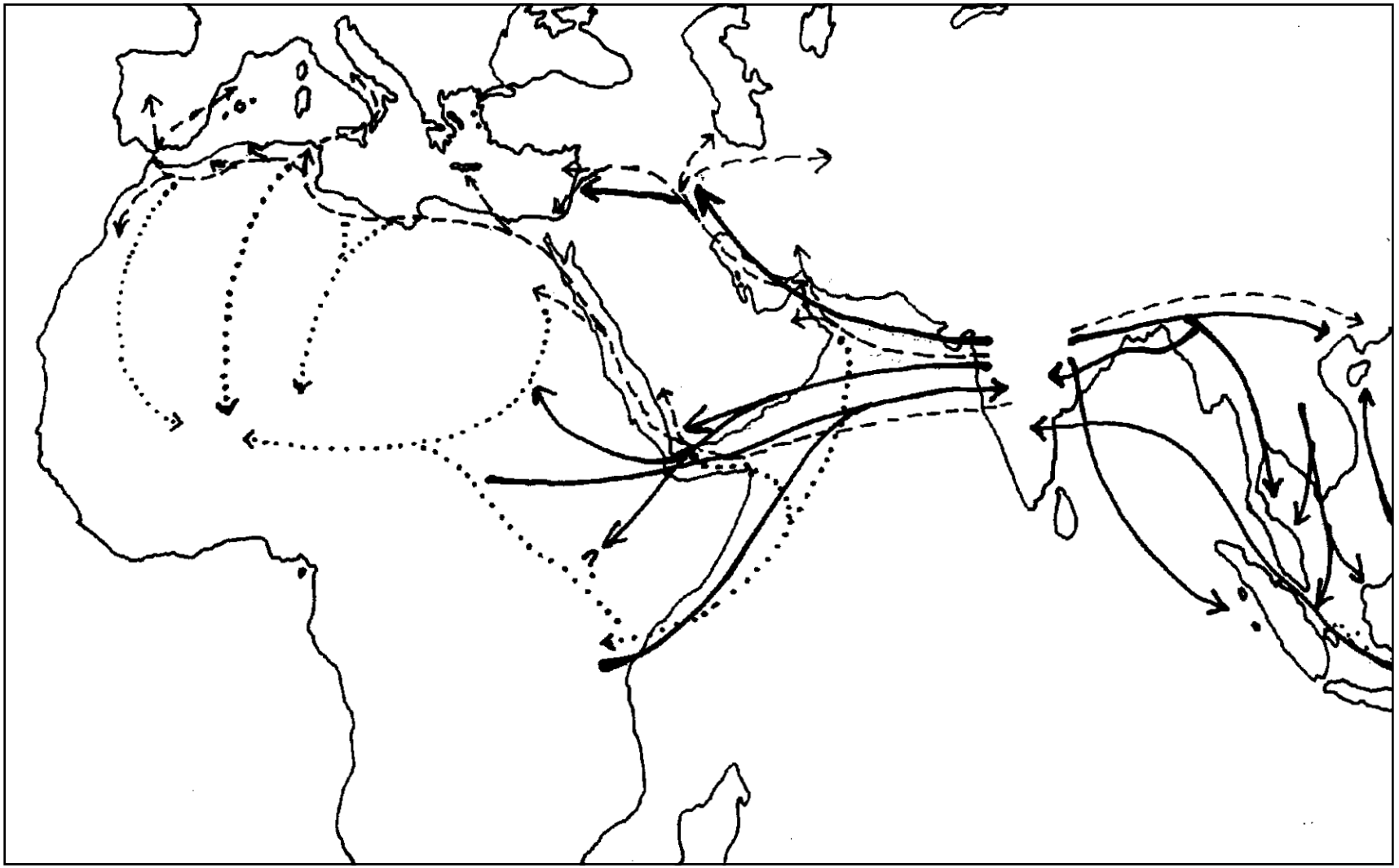
BOTANICAL AND ZOOLOGICAL TRAVELERS

FOOD TRANSFERS ACROSS MUSLIM LANDS BEFORE THE AGE OF EXPLORATION

Each of these crops originated in one part of the world, but spread to distant lands, and sometimes very different climates. The crops mentioned also played extremely important roles in the economies of certain lands and in certain historical periods. On this page, following the name of each food item, guess in what part of the world it may have originated. Think about why each food item has been important in history and/or in our own time. On the following pages, read about the origins and spread of these important foods, and use the information to fill in the chart with your summary of the information. Refer to the map on the next page for paths of crop diffusion.

FOOD	REGION OF ORIGIN	IMPORTANCE
Coffee		
Citrus Fruit		
Cotton		
Sugar Cane		
Hard Wheat		
Tomatoes		
Rice		
Turkey		
Spinach		
Banana		

MAP: BOTANICAL TRAVELERS



Routes of diffusion for various crops through the Muslim world, adapted from Andrew M. Watson, *Agricultural Innovation in the Early Islamic World* (Cambridge: Cambridge University Press, 1983).

Map Key:

Pre-Islamic diffusion routes

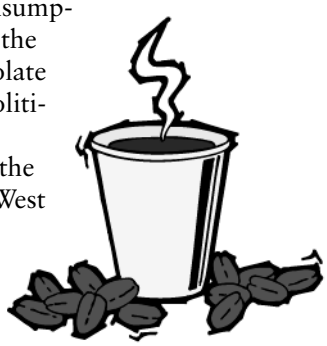
Diffusion routes in Islamic times to 1500

Probable diffusion routes in Islamic times to 1500

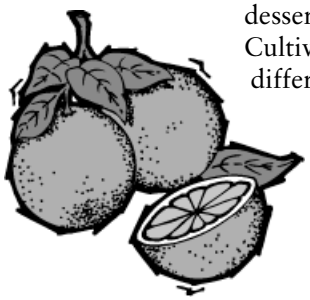
BOTANICAL AND ZOOLOGICAL TRAVELERS

COFFEE

In early Islamic times, coffee began to be grown in Arabia, near the Red Sea. Coffee cultivation did not, however, become important until the 15th and 16th centuries, when many trees were planted in Yemen, and the taste for coffee began to spread to other Muslim lands. Coffee merchants became very wealthy in cities like Cairo, and coffee drinking spread to Europe. After a Turkish diplomat introduced it to Parisians in 1669, the consumption of coffee skyrocketed in Europe during the 17th century, with the growth of coffeehouses that also sold two other new drinks—chocolate and tea. Coffeehouses played an important role in the social and political life of European cities.[40] Like sugar, coffee was introduced into Europe's overseas colonies, and became a vital cash crop. In 1714, the French brought a live cutting of a coffee tree to Martinique in the West Indies. With this single plant, the coffee business in Latin America began. Today, it is a major source of revenue for several African and Latin American countries. A global commodity, coffee may be a major contributor to the modern work ethic.[41]



CITRUS FRUIT



Lemons, limes and oranges were once rare, exotic items. A child who received a single orange as a gift would have been quite happy a few hundred years ago. Citrus fruits grow on trees whose fragrant blossoms made them a favorite in royal gardens. The use of citrus juice and rinds in cooking, as marmalade, as refreshing juice, in candied lemon and orange rinds as dessert treats, and various cosmetic and medical uses helped this crop spread around the world. Cultivation of citrus fruits began in China, India and Malaysia. Each region domesticated different varieties, like kumquat, sweet orange, sour orange, lemon and lime, and the citron. Grafting produced new varieties as cultivation spread. The citron probably reached the Mediterranean as early a s Biblical times, and at least in Roman times, but they were probably very rare. Other types of citrus had not spread west of India before Islamic times. Possibly reintroduced to the Mediterranean, the citron became widespread, and other types of citrus, like the lemon, the lime, the sour orange, and some hybrids are common in the literature by the 10th century. Spain became the most famous place for oranges and other citrus, with its famous gardens celebrated in poems and songs, and in groves planted by royal gardeners that still stand today, like the Patio de los Naranjos in Cordoba. From royal plantations to backyard gardens, citrus trees are part of Muslim culture. Citrus played an important role in the Age of Exploration itself, when captains learned to avoid scurvy (a seaman's disease caused by lack of vitamin C) in their crews by carrying preserved lemons or limes on board. English seamen, for this reason, were called "Limeys." After European explorers became established in India, they introduced certain varieties of sweet oranges to the rest of the world, but like cotton, the techniques for growing them had been learned centuries earlier and aided successful diffusion at that time. This may also be a case of multiple transfers from different sources. Citrus is an important global cash crop today, and a vital source of Vitamin C for people's health.

40. Ferdinand Braudel, *The Structures of Everyday Life, Volume 1*, (New York: Harper & Row Publishers, 1979), pp. 256-260.

41. "Coffee," *Microsoft® Encarta® 96 Encyclopedia.* © 1993-1995 Microsoft Corporation. All rights reserved. © Funk & Wagnalls Corporation.

COTTON

This fiber crop may have originated in India or ancient Egypt, and its textile varieties and cultivation techniques were certainly developed in India. Indian cotton goods were exported widely from India in ancient times across the monsoon and overland routes, but its cultivation spread slowly. During pre-Islamic times, it had spread into China, and probably as far west as East Africa. Much of this early diffusion, however, is cotton of an annual variety. High-yielding annual varieties of fine cotton fiber and their widespread cultivation diffused as a result of the economic development of Muslim lands, with their vast production of textiles of all kinds. Cotton was grown on a very wide scale, and processed at many centers. This new cotton plant spread as far as the frontiers of Christian Europe and Sub-Saharan Africa. Knowledge of varieties and techniques for growing cotton became known to the Spanish, and became very important in the New World. There, Old World familiarity with cotton and the methods for growing it united with New World varieties that produced longer fibers. With that, another of the cash crops that supported European colonization and economic growth of the Americas was born. Importation of these varieties back into the Old World gave the early industrial revolution a great push. The cotton mills of England, by 1830, were importing raw cotton from the Middle East and the American South, and selling calico printed cottons (whose styles and techniques were learned at Calicut, India) all over the world, fueling both industrial revolution and the growth of empire. Cotton, the word for which came through the Arabic *qutn*, also contributed to the development of the United States' economy and its global trade. On a personal level, cotton has also played a role in providing inexpensive, comfortable clothing for the masses that has contributed to health and hygiene, in the form of underwear and sportswear.

SUGAR CANE

This is another "industrial crop" that has had a major impact in agriculture, economics and social life around the world. It may also have encouraged the professional development of dentistry more than any other food. Sugar cane produces more human food per acre than anything else known, and it has many uses. Its juice can be sucked raw or the stalk cooked and eaten. Its best-known use is refined sugar, crystallized from the juice boiled to syrup. Depending on how many boilings, it may be brown, red or white. Molasses is a mineral-rich byproduct of making sugar. The crushed cane is excellent for feeding cattle. Sugar cane, like so many other important crops, was originally cultivated and refined in India, Southeast Asia or Indonesia, from a wild grass high in sugar content. It has been grown for so long that it is not known when it was first domesticated; it may have reached China as early as 1000 BCE, and may have reached Yemen and Persia by the 7th century. Small amounts of sugar may have been exported to the West as medicine or royal curiosity in ancient times.

Cultivation of sugar cane, sugar refining, use in cookery and export spread with the prosperity of lands and cities under Muslim rule. From Persian areas to the Levant, from there to North Africa and on to Spain and Muslim Sicily, sugar cultivation and refining followed the spread of Arab and Muslim culture. By 1500, it had reached some islands in the Atlantic, like Madeira and the Canaries. It was produced in large scale for domestic use and for export in Muslim lands, in India and China. Sugar, along with its name, derived from the Arabic *sukkar*, most likely became known to Western Europe through contact with Spain. We can imagine the Christian rulers and elites adopting candies (also a word derived from Arabic) and sweetened desserts from their Muslim counterparts. There is also literary evidence of this transfer. One of the lasting memories of the translator-scholars who visited Toledo's famous libraries must have been marzipan, a confection of almond paste and sugar, which was a specialty of the city. The Crusaders tasted sugar and saw it growing in the Levant. European visitors to the Ottoman court tasted Turkish delight and other sweet pastries, and wrote rapturously about it to folks

back home. Nevertheless, sugar remained a luxury until the 17th century, when supplies from sugar plantations, worked by slave labor, began to arrive in larger quantities. Sugar is another cash crop that financed Europe's colonization of the world, both as refined sugar and as rum, one of the products of the triangular trade that bought African slaves. The popularity of sugar in Europe stimulated production in other places, too, and another global commodity was born. In 1747, German chemist Markgraff isolated sugar from the sugar beet. This brought the sweetener within reach of northern climates and within the budget of the masses. Sugar had conquered the world and made fortunes for many.

HARD WHEAT

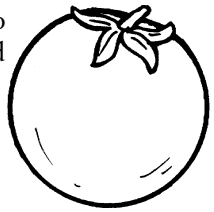
(pasta and semolina)

Italian food calls to mind pasta and sauce, but it might surprise you to know that both tomatoes and the grain—hard wheat—used to make all sorts of pasta, were introduced not too many centuries ago to Italy and the rest of Europe. Pasta is an invention of long distance travelers. Hard wheat was ground into flour, mixed with water and salt to make a dough and sieved into cous-cous, formed into small balls, rings, or tubes that could be strung on strings to dry, or laid in the sun. A highly nutritious, compact traveling food that stored well for a long time, it needed only to be boiled in water to eat. It could be mixed with meats, beans and sauces. Hard wheat is important because it can grow with less rainfall than other types, and it can also be stored longer without spoiling. Hard wheat contains a lot of gluten—the substance that makes its dough very elastic. Its flour is also excellent for making flatbreads.

Hard wheat may have originated in East Africa or the Eastern Mediterranean, but its cultivation spread widely under Muslim influence. It became an important crop in Spain and Italy, from where it spread to Europe. Along with the spread of hard wheat, which is high in gluten, went the art of making many forms of pasta. The proof of its spread to Europe from Muslim lands lies in the various words for noodles derived from Arabic terms. Thin pastry is also a product that must be made with hard wheat flour.

TOMATOES

The other spaghetti ingredient—tomato sauce—didn't appear until tomatoes were brought from the Americas during the Colombian Exchange. Tomatoes were first thought to be poisonous, as members of the nightshade family, but they soon caught on, and became so much wedded to Mediterranean and Middle Eastern cooking that it is hard to imagine that they are not a very old food item in the region. The rapid spread of tomatoes around the world offers a good example of rapid global diffusion of new products and foods after 1500, when the routes of the Columbian Exchange linked up with existing cultural connections in the Old World.

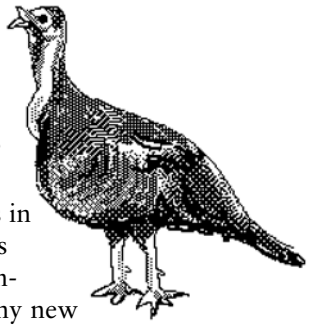


RICE

This grain, of course, originated as a food crop in the Far East, except for some wild varieties in the Americas and elsewhere. Rice is the only grain that can be eaten just by boiling it; most others must be ground into flour. Rice offers excellent nutrition and high yield per acre. Rice, however, can only be grown where there is enough water for the fields to be flooded for the young plants; therefore, rice cultivation spread hand-in-hand with Muslim irrigation technology and widespread organization. A staple food crop in the Far East, rice was often a luxury, though a very popular one, in other lands where it is not so heavily cultivated. Muslim farmers, merchants and even royalty and scientists contributed to bringing cultivation of Asian rice from China and Southeast Asia into Muslim lands around the Mediterranean, then on to East and West Africa, to Spain and to Italy, where techniques of cultivation were passed on to Europe. Rice was also imported into Europe from Muslim lands, as it does not grow in colder regions. Rice and its cultivation played a decisive role in the colonization of the Americas, where it was an important crop used to feed slaves. It was grown together with cotton and with sugar cane to feed those who labored on the plantations. It also became an American food staple that is still grown.

TURKEY

While this form of poultry is not a "botanical traveler," it is definitely a gastronomical, or gourmet traveler. The turkey is, of course, next to the Bald Eagle, the United States' national bird, consumed in commemoration of the First Thanksgiving in Massachusetts after 1620. The Turkey grows wild in North America, and was one of the food products exported from the New World to the Eastern Hemisphere in the Columbian Exchange. Would it surprise you to know, however, that the Mughal Emperor enjoyed a turkey dinner before the pilgrims in the American colonies? Not only did he enjoy the great bird at dinner, the avid naturalist Emperor Jahangir requested that his court illustrator paint its likeness in a book, in 1612.[42] Interestingly, the name given to the bird also shows something about perceptions of its origin. In an age without mass communication, a new food might be attributed inaccurately. Since so many new things were entering Europe from Ottoman lands during the 1700s, perhaps it was assumed that the turkey was originally consumed at the Ottoman Sultan's table. The Arabic name for the bird is the equivalent of "Roman Rooster," a reference to Istanbul, formerly the Roman capital of Constantinople. The pineapple, New World symbol of hospitality, went around the world at about the same time as the turkey, by the same routes.



SPINACH

This vitamin-rich vegetable crop originated in Nepal, and was taken west to Persia, south to India and east to China. When it was encountered by the Arabs with the spread of Islam, one writer called it "The Queen of Vegetables." Both the vegetable and its Arabic name *isbanakh* spread with Arab culture and cookery around the Mediterranean. It probably spread into Europe with the migrants who settled in Spain and Sicily, then on to the rest of Europe.

BANANA

This versatile crop, which can be eaten raw or cooked, ripe or green, is an important source of phosphorus, vitamins and starches. It has been called one of nature's "perfect foods." Bananas have been cultivated for thousands of years, but had scarcely spread farther west than India before Islam, though it may have spread to Arabia and East Africa via the monsoon routes. As early as the 8th century, however, banana cultivation had begun to spread rapidly across the lands under Muslim rule. By 1500, it had spread across Africa from east to west, around the Mediterranean to Spain, far beyond its original homeland in tropical South and Southeast Asia. It remained only for the Age of Exploration to bring the fruit across the Atlantic, along with the technique for reproducing it (it does not grow from seed, but from cuttings). In warm, wet regions of the Americas, of course, it became a staple food and such an important cash crop that it gave birth to the term "Banana Republic" for a country dependent on export production of this major consumer item. Interestingly, the word *banana* can be found in the *Qur'an*, meaning "fingers of the hand," though the word for the fruit in Arabic is *mawz*.

42. Paul Lunde, "New World Foods, Old World Diet," *Aramco World Magazine Special Issue: The Middle East and the Age of Discovery*, Vol. 43, No. 3, p. 49.

The list of foods and agricultural products, in addition to animals, that spread via the medieval Muslim routes of diffusion is long, though only a few have been listed here. Sorghum and taro root—important staple foods for millions, as well as melons, artichokes, eggplants, coconuts, and not to forget spices like pepper, cloves and cinnamon that explorers and merchants risked their lives to get. All of these agricultural products diffused to Western Europe and beyond through the extraordinary mobility that prevailed in the Muslim lands. Among other important industrial crops are indigo (the dye used for denim jeans) as well as coconut fiber and hemp for ropes, ship rigging, and burlap sacks. From the 8th century on, silk fiber was supplied to the whole hemisphere, except China and Southeast Asia, from Muslim production centers in Khurasan, the Caspian seaboards, western Iran, Armenia, Syria and al-Andalus (Muslim Spain). There was enough for both silk production in the Muslim regions and for export to Byzantium, which depended on Muslim producers for its supplies of raw silk. When Italy and France took up production in the late medieval and Renaissance period, well into the 19th century, Levantine centers in Lebanon, Syria and Palestine supplied raw and semi-finished silk thread.

Animal breeds were also important products, as were the skills needed to raise them successfully, and sometimes to train them for particular uses. The Arabian horse is perhaps the best known, but other varieties, especially Turkish breeds, were also disseminated via Muslim military experts, rulers, breeders, writers on veterinary practices, and geographers. Breeds of sheep, of cattle, and of birds like the hunting falcon were also important exports across Muslim lands and on to Europe.

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PRIMARY SOURCE ACTIVITY

THE PLAGUE ACROSS CULTURES

PART 1: PRELUDE TO DISASTER

Sometimes people are accused of being "ethnocentric", a word which is made up of the Greek word "ethnos" meaning people, or society, and the word "center", indicating that which is focused (or centered) upon. When one is said to be "ethnocentric" it means that they look at things through the eyes of their own culture and are unable to see things as individuals from another culture might view them. One can also be "tempocentric", meaning that events are viewed through the eyes of the viewer's **contemporary time-frame**, without giving any thought of how things may have look different during another era.

- Try to put yourself in another culture and time: the place is Paris, France, the time is 1348. Read **Document #1**, "Prelude to Disaster." Keep in mind that even though you may not have been able to read during the 14th century, you would, nonetheless, have been quite familiar with the story of the Day of Judgment which is described in the Biblical Book of Revelation, and that even though some of these writings may have seemed strange and difficult to comprehend, you would still have taken the teachings of this chapter quite seriously.
- Read the excerpts from the Book of Revelations and then write a journal or diary entry *as if you are a teenager living in France in August, 1348; the day after the comet fell on Paris*. Describe how you feel, what you have heard on the streets, and what you see on the streets of your city as word of the comet is spreading among the inhabitants of your neighborhood. Keep in mind that you would probably also be aware of the fact that the Book of Revelation ends on a note of promise and mercy as it describes the salvation of mankind through their belief in Christ and offers a ray of hope to those who live in righteousness.
- Read **Document #2**, "How Did People React to the Bubonic Plague?" Write in your journal how you are reacting to the approaching plague. Would you feel as though there is hope for you and your loved ones to make it through this "trial" or do think you would feel complete despair? Why do you think you would feel that way? Do you think people your age felt the same during the 14th century?

TEACHER'S NOTE: You may want to turn off the classroom lights and use candlelight while the students are writing their "journals". It would give students an idea of what it was like to write by candlelight as they are traveling back in time.

PART 2: IMPACT OF THE BLACK DEATH

1. Read **Documents #3 and #4** entitled "Impact of the Black Death: Europe" and "Impact of the Black Death in the Muslim Middle East".
   - Compare and contrast the effects of plague in the two societies.
   - Sometimes, during a time of crisis, things of little value can suddenly seem precious and vice versa. Do you see any sign of that happening in either culture? What do you think was the cause of this?
2. Make a list of items that you think would increase in value today if a plague of this magnitude were to arrive. How does that list compare to the listings in these two documents?

PART 3: UNDERSTANDING THE PATHOLOGY OF PLAGUE

These activities are designed to give students an understanding of how the Bubonic Plague manifested itself, and how people responded to the plague in different parts of the world. Students will read some primary documents and draw conclusions from them.

I. Read **Document #7** ("Eye-Witness Descriptions of the Plague" by Ibn Battuta and al-Maqrizi) to get a better understanding of how this disease manifested itself. Then read **Documents #5 and #6** which list the protective measures and medical treatments followed by the inhabitants of Europe and the Muslim lands. You will see many ways in which they are similar and many ways in which they differ.

   A. On the blackboard, write four column headings:

      RELIGION

      SUPERSTITION

      FOLK BELIEF AND TRADITION

      SCIENCE OF MEDICINE

   B. List the actions taken by those in Europe under the appropriate headings. Then in another color chalk, list those taken by people living in the Muslim lands. Which of the four segments is the dominant one in each case, and which is the least utilized? Discuss why you think this is the case.

II. Re-read the following items which were listed in Document #5:

   A. "Emeralds, gold, pearls were thought to be medicinal"

   B. "It was believed that "bad cured bad"; latrine attendants were almost always immune to the plague, so some people spent long hours crouched over latrines absorbing the foul smells."

III. Discuss how the issue of economic status and standard of living may have influenced how the plague effected different segments of society.

   A. Do you think there may have been some truth to the fact that people who wore emeralds, gold and pearls had a lower death rate than the rest of the population? Would this have caused people to believe that it was the jewels themselves that offered protection? What do you think about this belief?

   B. There was not an efficient sewage system in Europe during the time of the plague. Toilets were emptied by people called "Latrine attendants". Why do you think someone as poor as a latrine attendant would have such a low rate of death that people were willing to sit over human waste and smell the fumes as a way to protect themselves from the Black Death? Do you think their attempts made any sense in a practical, medical sense?

IV. Discuss how people, even though they meant well, may have unknowingly spread the plague in their efforts to stop the disease.

Document 1

PRELUDE TO DISASTER IN EUROPE: SIGNS OF THE COMING PLAGUE

As the time of the Black Plague was approaching, many other disasters had already led Europeans to believe that the end of the world was coming. There had been a series of events within the Christian Church itself which had shaken the confidence of Latin Europe. The fact that the Crusades failed to retake Jerusalem spread apprehension throughout the Christian world. Diseases, crop failures, natural disasters, religious upheavals and starvation reminded the European of the Middle Ages that life was frail and that death and destruction could be at one's doorstep with little warning. These realities had the population trembling in dread of the final judgment day which was a very real fear in their lives.

Keep in mind that religion in Europe at that time was so important to the average individual that it formed the very core of their lives. The local church or cathedral was the hub of local activities and excommunication from the church was tantamount to a death sentence—it meant that you were condemned to eternal damnation as an outcast from established religion. This life on earth was seen as a temporary, fleeting experience. The **real** goal of existence was to behave in a pious manner and believe in Christ's redeeming powers in order to secure a place in heaven and avoid the fires of hell. People spent much of their time, energy and conversation discussing the approaching Judgment Day. It is significant to note that the great cathedrals of Europe greeted their visitors with religious themes carved into the stones surrounding the entrance doors. Some of these carvings depicted gruesome Hell scenes while many depicted Christ as the Redeemer. These scenes were meant to teach a largely illiterate populace that Judgment Day *was* coming, and that the Devil was as anxious to grab souls as the Angels were.

Historical events of the 11th and 12th centuries had introduced times of fear and apprehension for Latin Christendom as the following events took place:

- In 1054 at the Council of Chalcedon, "The Great Schism" took place. Christianity seemed to be ripped apart by conflict, with the Eastern Orthodox Christians refusing to recognize the Roman Catholic Pope as the supreme leader of all Christianity. They turned instead, to the Patriarch of Constantinople for their spiritual guidance and political leadership. With the Eastern Orthodox Christians being strategically placed along the Silk Route, the difference in lifestyle, educational level and wealth between the two Christian worlds became pronounced, with Europe falling rapidly behind. This added to the antagonism between the two centers of Christianity.
- In 1071 at the Battle of Manzikert (in present day Turkey) the Saljuq Turks came sweeping out of Central Asia, laying waste everything in their path. They attacked the Byzantine (Eastern Orthodox) Christian empire based in Constantinople. Making the problem more frightful was the fact that they were converting to Islam, and seemed to be on a collision course with Christianity.
- The First Crusade reached the Holy Land in 1099 and Christians saw a ray of hope in their successful attack on Jerusalem. The Crusaders joyously took the holy city back from the Muslims, but in their vigor and enthusiasm, not only did they massacre many Muslims, they also killed thousands of Eastern Orthodox *Christians* who were residents of Jerusalem! They then proceeded to burn to death the Jews of the city who had taken refuge in the synagogue. Europe's feeling of excitement over this victory was mingled with a sense of shock and shame as news spread of the slaughters.
- In 1187 Muslim forces under the leadership of Salah al-Din (Saladin) re-took Jerusalem from the Christians. In the meantime, the second and third Crusades were dismal failures; something that was taken as a sign of God's displeasure with the holy warriors of Christianity.

- In the Fourth Crusade in 1204 the Roman Catholic Crusaders from Europe were on their way to get Jerusalem back from the Muslims when they were "distracted" from their mission. They defeated and ransacked Constantinople, *a fellow Christian city*, where they killed thousands of civilians and stole household goods, church items, gold and great works of art from the Eastern Orthodox Christians. Europeans were appalled by the behavior of the Crusader knights. They became afraid that God would soon be punishing mankind for this sin, and refused to offer any real support for the unsuccessful "lesser Crusades" which followed.

Adding to the troubles of the time was a series of particularly dreadful **natural** disasters as well as some short-lived, but virulent plagues which hit Europe during the centuries preceding the arrival of the Bubonic Plague of the 14th century. The 13th century saw crop failures, economic inflation, starvation and famine. The 14th century opened with famine in Europe and seemed to continue a pattern of destruction and misery:

- In 1310 torrential rains destroyed the harvest and brought on famine.
- From 1315-1317, famine spread throughout most of northern Europe.
- Up to one-tenth of the population of some of Europe's cities were wiped out by an epidemic of Typhoid Fever in 1316.
- In 1318 a disease hit Europe's cattle and sheep, destroying a major source of food, income and warm, woolen clothing. The economy fell into hard times because of the temporary decrease in the production of wool. Markets were closed and merchants and farmers who had lost their livelihood were unable to feed their families.
- In 1322, 1329, and 1332, harvests failed again. Some desperate peasants managed to survive the winter on raw herbs. They eventually got to the point where they were eating tree bark and soil mixed with soup in an effort to survive. [43]

News from the East

To make matters even worse, word had spread of terrifying disasters that were hitting the Far East. With the rapid growth of world trade at the end of the Crusades, Europe was emerging from her isolation from the rest of the world. Places like China and India, while still being seen only by the most adventuresome travelers and merchants, didn't seem quite so distant and unconnected as they had before. With thoughts of the end of time, and Judgment Day in their minds, the stories of troubles in the Far East began to send ripples of fear through devout Christians, as the tales became more and more fantastic. In 1333 a drought and famine ravaged parts of China. Then floods killed 400,000 people. Next, the mountain Tsincheous "fell in" (a volcano?). The following year saw millions of locusts devouring crops which were meant for human consumption, and people heard "underground thunder" (an earthquake?) in 1345. An anonymous Flemish cleric wrote in 1346:

> ❝ *In the East, hard by Greater India…horrors and unheard of tempests overwhelmed the whole province for the space of three days. On the first day there was a rain of frogs, serpents, lizards, scorpions and many venomous beasts of that sort. On the second, thunder was heard, and lightning and sheets of fire fell upon the earth, mingled with hail stones of marvelous size which slew almost all.…On the third day there fell fire from heaven and stinking smoke, which slew all that were left of men and beasts, and burned up all the cities.…By these tempests the whole province was infected; and it is conjectured that, through the foul blast of wind that came from the south, the whole seashore and surrounding lands were infected, and are waxing more and more poisonous from day to day.*[44] ❞

43. McKay, Hill and Buckler, ***A History of Western Society, 5th edition***, (Boston: Houghton Mifflin Company, 1991), p. 372.

44. Philip Ziegler, ***The Black Death***, (NY: John Day Publishing Co., 1969), p. 14.

Other writers told tales of a great war which had taken place between the sea and the sun in the Indian Ocean. The waters of the ocean were supposedly drawn up as vapor which had been contaminated by the abundance of dead and rotting fish who had perished in the battles. This poisonous mist was thought to be traveling through Persia (present day Iran) where it contaminated all that it touched. It is obvious that by 1346 Europe was aware of a mysterious killer which was traveling westward from China, wreaking death and destruction in its path. This belief in a poisonous mist (called *Miasma* or "Bad Air") was to become the leading factor in the attempts by physicians to cure the disease.

An Alarming Vision on a Summer's Eve

The final sign of doom was seen on a starry evening in Paris in August of 1348. As worshippers were departing from evening services an eerie vision greeted them in the sky. Jean de Venette, a 14th-century French friar (who was to survive the plague) wrote of the celestial visitor in the following way:

> "*In the month of August, 1348, after Vespers (evening prayers) when the sun was beginning to set, a big and very bright star appeared above Paris, toward the west. It did not seem, as stars usually do, to be very high above our hemisphere but rather very near. As the sun set and night came on, this star did not seem to me or to many other friars who were watching it to move from one place. At length, when night had come, this big star, to the amazement of all of us who were watching, broke into many different rays and, as it shed these rays over Paris toward the east, totally disappeared and was completely annihilated. Whether it was a comet or not, whether it was composed of airy exhalations and was finally resolved into vapor, I leave to the decision of astronomers. It is, however, possible that it was a presage (warning) of the amazing pestilence to come, which, in fact, followed very shortly in Paris and throughout France and elsewhere, as I shall tell. All this year and the next, the mortality of men and women…was so great that it was almost impossible to bury the dead…He who was well one day was dead the next and being carried to his grave.*[45]"

Poor harvests continued almost non-stop until 1348, by which time the population of Europe was undernourished, overworked and weak with fatigue and the psychological stress caused by the uncertainty and frailty of life…just in time for the Grim Reaper to arrive in the form of the Bubonic Plague!

The Bible as a Warning to Mankind

One of the most influential and well-known readings of the time was the *Book of Revelation*, the last book of the New Testament, which warns of the extensive death, destruction and natural disasters that will serve as the feared sign that Judgment Day has arrived. This book is considered a prophetic revelation of things to come. It was written in approximately 95 CE to inspire Christians to face with courage the catastrophic events which were expected in the future.[46] This Biblical passage indicates that God would soon intervene in human affairs to end the existing world order and open a new age, but that Christians of absolute faith would be redeemed by the intervention of Christ's salvation while those of little or no faith would be met with eternal doom. The *Book of Revelation* begins with seven letters to the seven churches of Asia Minor. Next come strange, horrifying visions whose meanings are difficult to understand. These visions are seen by the apostle John, who is in Heaven, witnessing the opening of seven seals and the blowing of seven trumpets by angels. There are seven oracles of the last days.

45. Perry, Peden and Von Laue, *Sources of the Western Tradition, Vol I*, (Boston, MA: Houghton Mifflin Company, 1991), p. 268.

46. Zondervan Publishers, *The Holy Bible, Revised Standard Edition*, "Introduction and Reading Guide," p. 13.

Even those Christians who could not read or write were very familiar with this Book because it seemed to speak to their times so well. In their minds it was as if the events being warned of were seen all across the known world. Sermons of church leaders as well as religious discourse on the streets told the tales of the *Book of Revelation* time and time again until the average person could offer a detailed description of the signs of the last days.

The Book of Revelations

CHAPTER 6

Now I saw when the Lamb opened one of the seven seals, and I heard one of the four living creatures say "Come!" And I saw, and behold, a white horse, and its rider had a bow; and a crown was given to him, and he went out conquering and to conquer.

When he opened the second seal, I heard the second living creature say "Come!" And out came another horse, bright red; its rider was permitted to take peace from the earth, so that men should slay one another, and he was given a great sword.

When he opened the third seal, I heard the third living creature say "Come!" And I saw, and behold a black horse, and its rider had a balance in his hand; and I heard what seemed to be a voice in the midst of the four living creatures saying, "A quart of wheat for a denarius (a day's wage for the laborer), and three quarts of barley for a denarius, but do not harm oil and wine!"

When he opened the fourth seal, I heard the voice of the fourth living creature say "Come!" And I saw, and behold, a pale horse, and its rider's name was Death, and Hades (Hell) followed him; and they were given power over a fourth of the earth, to kill with sword and with famine and with pestilence and by wild beasts of the earth.

When he opened the fifth seal, I saw under the altar the souls of those who had been slain for the work of God and for the witness they had borne (Christian martyrs). They cried out with a great voice, "O Sovereign Lord, holy and true, how long before thou wilt judge and avenge our blood on those who dwell upon the earth?" Then they were given a white robe and told to rest a little longer, until the number of their fellow servants and their brethren should be complete, who were to be killed as they themselves had been.

When he opened the sixth seal, I looked, and behold, there was a great earthquake; and the sun became as black as sackcloth, the full moon became like blood, and the stars of the sky fell to the earth as the fig tree sheds its winter fruit when shaken by a gale. The sky vanished like a scroll that is rolled up, and every mountain and island was removed from its place.

The Book of Revelations

CHAPTER 8

When the Lamb opened the seventh seal, there was silence in heaven for about half an hour. Then I saw the seven angels who stand before God, and seven trumpets were given to them. The first angel blew his trumpet, and there followed hail and fire, mixed with blood, and a third of the trees were burnt up, and all green grass was burnt up.

The second angel blew his trumpet and something like a great mountain, burning with fire, was thrown into the sea, and a third of the sea became his blood.

The third angel blew his trumpet, and a great star fell from heaven, blazing like a torch, and it fell on a third of the rivers and on the fountains of water, and many men died of the water because it was made bitter.

The fourth angel blew his trumpet, and a third of the sun was struck, and a third of the moon, and a third of the stars, so that a third of their light was darkened.

Then I looked and I heard an eagle crying with a loud voice, as it flew in midheaven, "Woe, woe, woe to those who dwell on earth, at the blasts of the other three trumpets which the three angels are about to blow!"

The fifth trumpet brought a plague of locusts which descended upon earth to torture mankind, but not to kill them. …[They were described as follows:] "They were like horses arrayed for battle; on their heads were what looked like crowns of gold; their faces were like human faces, their hair like women's hair, and their teeth like lion's teeth. They have tails like scorpions, and stings, and their power of hurting men lies in their tails."

The sixth trumpet released the angels who were waiting to kill a third of mankind with plague.… [They were described as follows:] "The riders wore breastplates the color of fire and of sapphire and of sulfur, and the heads of the horses were like lions' heads, and fire and smoke and sulfur issued from their mouths."

The seventh trumpet brought a battle between forces of good and evil; a battle involving beasts, dragons and other animals. Then came warnings of evils which will befall the non-believers, including torture in hell, earthquakes, floods, plague and drought.

The chapter ends with a message of hope as well as a message of warning. A "New Jerusalem" was promised as well as a drink of the "water of life" for those who believed:

And he said to me, "Do not seal up the words of the prophecy of this book, for the time is near. Behold, I am coming soon, bringing my recompense, to repay every one for what he has done. I am the Alpha and the Omega, the first and the last, the beginning and the end." He who testifies to these things says, "Surely I am coming soon." Amen Come, Lord Jesus! The grace of the Lord Jesus be with all the saints. Amen.[47]

47. ***The Holy Bible, Revised Standard Edition*, pp. 239-250.**

Document 2

HOW DID PEOPLE REACT TO THE BUBONIC PLAGUE?

In 14th-century Europe there were mainly two responses to the horrors of the plague, both of them at different ends of a long spectrum. Some took the attitude that since an early death was inevitable, and that most of mankind was doomed to burn in hell, (otherwise, why would this pestilence be raining down on humanity with such a vengeance?). These people decided they might as well have a good time while they can. They simply turned to drinking, gambling, thievery, and relaxed sexual morals to cope with the situation until death conquered them.

Others leaned in the opposite direction, and turned to repentance, prayer and seeking the aid of the Church to intervene between mankind and God. Thousands of people enjoyed a renewal in religious fervor, and though many died, their faith in God and their belief in Heaven enabled them to die with hope in their hearts. Their faith in the Church, however, also led to the expectation that the Church could "do something about this". When the Church failed to come up with any methods of intervention, some lost faith in their religion and died in despair. In fact, one of the outcomes of the plague was a shifting in the balance of power in Europe as some religious leaders were no longer able to maintain total political and religious control of their cities as they had done before.

One group, called the "Flagellants", traveled throughout the countryside beating themselves with chains in order to display their repentance for the sins of ALL mankind. As the plague spread throughout Europe, people felt a stronger and stronger sense of hopelessness and despair. They turned to many things for relief: superstition, immoral behavior, science, and the Church. But as the Christians saw the plague spread, sometimes as fast as five miles per day, they saw one helpless village after another fall victim to the scourge. The Flagellants decided that they would wander from village to town, beating themselves on the backs until bloody, while chanting Biblical verses and singing religious hymns. In this way, they hoped to suffer for the sins, not only of themselves, but of the local townspeople as well. Their intent was to repent for all the sins of mankind, and bring about salvation to those either living or dead who had suffered from the plague.

Below is an interesting description of the Christian Flagellants written by Jean de Venette, a 14th-century French friar and plague survivor:

> *"In the year 1349, while the plague was still active and spreading from town to town, men in Germany (and) Flanders…uprose and began a new sect on their own authority. Stripped to the waist, they gathered in large groups and bands and marched in procession through the crossroads and squares of cities and good towns. There they formed circles and beat upon their backs with weighted scourges, rejoicing as they did so in loud voices and singing hymns suitable to their rite and newly composed for it. Then for thirty-three days they marched through many towns doing their penance and affording a great spectacle to the wondering people. They flogged their shoulders and arms with scourges tipped with iron points so zealously as to draw blood.[48]"*

IMPACT OF THE BLACK DEATH: A LOOK TOWARD THE RENAISSANCE

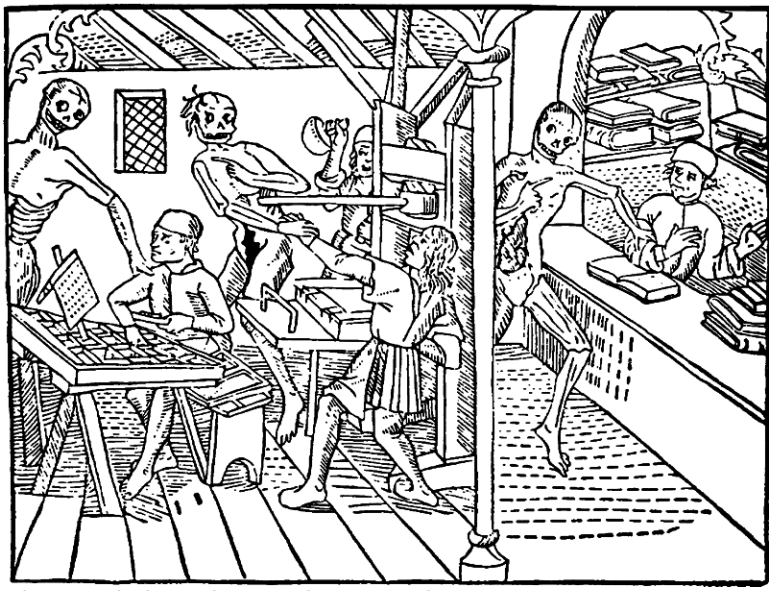
By the time the Bubonic Plague came to an end, many changes had come about within many parts of the world. (See documents listing the impact of the Black Death) The populations of Europe and the Muslim lands were so devastated that changes came about in the social order, religion, economics and particularly, in man's attitude about himself. People who had survived the plague felt a new confidence as they realized that they now had more economic clout (due to a reduced labor force). They also questioned authority as they never had done before. Powerful church leaders, the landed aristocracy and politicians were no longer able to maintain the kind of control they had wielded before the devastations of the 13th and 14th centuries. By 1381 Europe was again shaken, but this time, by a massive Peasant Revolt which altered the social structure of Medieval Europe and looked toward the changes we refer to as the "Renaissance".

48. Perry, Peden and Von Laue, p. 270.

Document 3

IMPACT OF THE BLACK DEATH IN EUROPE [49]

- Depopulation! 1/3 of the population died (estimated 20 million deaths).
- Displacement of the population: Jews fled to Eastern Europe, peasants settled abandoned lands.
- Families were abandoned. Children were abandoned by parents.
- Political instability led to the Peasant Revolt of 1381 in England.
- Cities grew as production centers.
- Wages increased for labor because of depopulation. Because there were fewer workers, they could charge more money.
- Distribution of wealth in society changed.
- Royal monarchies became stronger due to increased urban populations and their need for security.
- The plague created an opportunity for monarchs to increase the tax base and size of armies by providing protection for towns.
- Prices increased while commercial activities decreased.
- Criminals flocked to the cities. Crime rates rose.
- Papacy became more secular and preoccupied with fiscal gain and universal power.



Plague visits death on workers in a 15th-century printshop.

- Disillusionment with the Church led to:
- Increase in religious fervor:
  - increase in number of religious holidays
  - increase in religious pilgrimages
  - the sale of indulgences by the Pope (you could "buy" your way into heaven by giving money to the Church)
- Increase in hedonism:
  - people lived for the moment, rejecting religious authority
  - They turned to drink, sex and materialism. (Their attitude was "have fun while you can; you'll be dead soon.")
  - Questioning of church authority. Set the stage for the Protestant Reformation.
- Economic situation changed; peasants and workers became more aware of their value as skilled artisans died and peasants took their place.
- Work days were extended due to drop in labor force. Night work became common. Clocks became important as a sense of urgency entered the culture, and the fact that many people were now working for someone else instead of bartering in goods they produced.
- Labor shortage stimulated the invention of machinery.
- Traditional authority figures were challenged.
- The Black Death is considered by some scholars to be the turning point from medieval to modern times due to the weakening of feudalism.

Document 4

IMPACT OF THE BLACK DEATH IN THE MUSLIM MIDDLE EAST [50]

- Shortage of funeral cloths and burial shrouds.
- Mosques closed as caretakers died.
- High cost of medicines.
- Cost of silver rose because of its use for magic talismans and amulets.
- Increased cost of medicinal ingredients, especially incense, cardamom and camphor.
- White sugar, watermelons, Syrian pears, molasses and pumpkin seed prices rose because of their use in making medicine.
- High cost of labor due to population decline.
- Crafts disappeared because of decline in demand. Artisans could earn more by transporting and burying the dead.
- Rulers in Cairo issued proclamations that craftsmen should resume their trade. Those who refused were beaten.
- Loss of artistic creativity as skilled artisans died. (The number of weavers in the city of Alexandria dropped from approximately 13,000 people in 1394 to 800 in 1434!)

A 13th-century illustration depicting a burial.

- Doctors, druggists, herb sellers and blood-letters became wealthy.
- Increase in endowments for religious, educational and charitable purposes.
- Government funds increased due to death duties and confiscation of property of victims.
- Technological stagnation. Role of Middle East as a trade center declined.

49. This list was adapted from the DeWitt Wallace Reader's Digest Fund 1991 Curriculum Module "Global Connections in the Era of Columbus" by Helen Finken, Helen Grady, Mary Price and Sue Roberson.

50. Ibid.

Document 5

PROTECTIVE MEASURES AND MEDICAL TREATMENTS IN EUROPE[51]

- Flight to escape diseases; low sites protected from the wind considered most desirable.
- Pope Clement VI retreated to Avignon where he slept night and day between two enormous fires.
- Coast was avoided due to the belief that "corrupt mists" were creeping across the surface of the sea, bringing the plague with them.
- Houses were built facing north; windows were covered with waxed cloth.
- Aromatic items like juniper, ash, vine or rosemary were burned to keep away the miasma (poisonous air).
- Magic amulets, talismans, hex signs, relics became popular.
- Quarantine of victims.
- Bad to sleep by day and best to keep the heat of the body steady by sleeping first on right and then the left.
- Sleeping on one's back was considered disastrous because poisonous fluids would invade the nose and mouth and flow to the brain and erase the memory.
- It was believed that bad cured bad; latrine attendants were almost always immune to the plague, so some people spent long hours crouched over latrines absorbing the foul smells.
- Bloodletting (draining some blood from the patient) to relieve fever and excess of blood in body. This was based on the belief that bad air increased the burning of the heart and thus increased the mass of blood which the heart could not control. Bloodletting was used to free the life force in the arteries.
- Soothing potions: blend of apple, syrup, lemon, rosewater, and peppermint.
- Emeralds, gold, pearls were thought to be medicinal.
- Eating eggs with vinegar was thought to ward off the plague.
- No confidence in medical science but doctors became wealthy because patients still sought their help.
- Pervasiveness of the plague was reflected in children's verse, "Ring Around the Rosie":

Ring around the rosie,	(Rosies represented pink rash of plague)
Pocket full of posies,	(Flowers were placed in pockets so scent would repel the plague with their sweet fragrance)
Achoo! Achoo!	(Achoo refers to coughs caused by the pneumonic form of the Black Death)
We all fall down!	(Everybody dies)

51. This list was adapted from The DeWitt Wallace Reader's Digest Fund 1991 Curriculum Module "Global Connections in the Era of Columbus", by Helen Finken, Helen Grady, Mary Price and Sue Robertson.

Document 6

PROTECTIVE MEASURES AND MEDICAL TREATMENTS IN THE MUSLIM MIDDLE EAST[52]

- Few people went into the streets, as observed in Cairo at the height of the Black Death in 1349.
- Flight was discouraged because initially, people did not believe in the contagious nature of the plague. There was deep concern that plague victims would feel neglected. It was felt that society must be preserved from such disruption and disorder.
- People were to improve their circumstances by cleaning and fumigating their houses.
- Letter magic (belief that the Arabic language was sacred and had magical qualities) based on the *Qur'anic* verse: "We send down verses of the *Qur'an,* which is a healing and a mercy to the believer."
- Renewed enforcement of Muslim laws, especially against alcohol and moral laxity (showing that some Muslims saw the plague as punishment for their sins).
- Muslims were told to have patience, piety and to visit the sick.
- Curses were discouraged. In Cairo today "Kubbah" still means "A plague on you!"
- "Bad winds" were purified by burning fires.
- Sweet smelling shrubs were planted around towns to guard against the entry of bad air.
- People were told to avoid congested areas where air might be corrupted by plague stricken people, and to be quiet as possible and moderate in breathing so that breathing was not accelerated.
- People were advised not to sleep after eating and to avoid missing meals or eating at irregular hours.
- Sleep with the room opened to the north.
- "Bloodletting" (draining some blood from the patient). (See document 6)
- Keep morale high by experiencing joy, serenity, relaxation and hope.
- Plague buboes (boils) were pierced and soaked with vinegar and oil of roses, apples and myrtle.
- Yolk of an egg, when dried was applied to heal the boils.
- Violets were rubbed on the body or a mixture of violets and water was drunk.
- Items given to strengthen the heart: fruit juices, scents of things such as roses, camphor and sandal; lentils with vinegar, and meats cooked in vinegar.
- Beds were covered with leaves of the khilaf tree, violets, roses, white lilies and other flowers.
- Cool, strong "coatings" (which we now think were plasters) placed on the heart.
- Drinks of sour fluids such as juice from lemons, pomegranates, grapes and onions.
- Seek pleasant and attractive company. (The best companion was believed to be the *Qur'an*.)

52. This list was adapted from The DeWitt Wallace Reader's Digest Fund 1991 Curriculum Module "Global Connections in the Era of Columbus", by Helen Finken, Helen Grady, Mary Price and Sue Robertson.

Document 7

EYE-WITNESS DESCRIPTIONS OF THE PLAGUE

Plague in Damascus

by Ibn Battuta, 14th-century Moroccan Traveler

> *"The people fasted for three successive days, the last of which was a Thursday. At the end of this period the amirs (princes), sharifs (respected families), qadis (judges), doctors of the Law, and all other classes of the people in their several degrees, assembled in the Great Mosque, until it was filled to overflowing with them, and spent Thursday night there in prayers and liturgies and supplications. Then, after performing the dawn prayer, they all went out together on foot carrying Qur'ans in their hands; the amirs too, barefooted. The entire population of the city joined in the exodus, male and female, small and large, the Jews went out with their Book of the Law and the Christians with their Gospel, their women and children with them; the whole concourse of them in tears and humble supplications, imploring the favor of God through His Books and His Prophets.* [53] *"*

Plague in Damascus

by al-Maqrizi, 14th-century Egyptian Historian

> *"The malady manifested itself in the following manner: a small swelling grew behind the ear which rapidly suppurated. There was a bubo under the arm and death followed very quickly. One noticed also the presence of a tumor which caused a serious mortality. They were occupied with this for a time; then they spat blood and the population was terrified by the multitude of the dead. The maximum of survival after the spitting of blood was fifty hours.*[54] *"*

53. Ross Dunn, ***The Adventures of Ibn Battuta***, (Berkeley: University of California Press, 1989), p. 270.

54. Michael W. Dols, ***The Black Death in the Middle East***, (Princeton, N.J. : Princeton University Press, 1977), p. 75

The Christian Flagellants

by Jean De Venette, 14th-century French Friar and Plague Survivor

> *In the year 1349, while the plague was still active and spreading from town to town, men in Germany…and…Flanders uprose and began a new sect on their own authority. Stripped to the waist, they gathered in large groups and bands and marched in procession through the crossroads and squares of cities and good towns. There they formed circles and beat upon their backs with weighted scourges, rejoicing as they did so in loud voices and singing hymns suitable to the rite and newly composed for it. Thus for thirty-three days they marched through many towns doing their penance and affording a great spectacle to the wondering people. They flogged their shoulders and arms with scourges tipped with iron points so zealously as to draw blood…They said that their blood thus drawn by the scourge and poured out was mingled with the blood of Christ. Their many errors showed how little they knew of the Catholic faith…Many honorable women and devout matrons, it must be added, had done this penance with scourges, marching and singing through towns and churches like the men, but after a little, like the others, they desisted.* [55]

55. Perry, Peden and Von Laue, *Sources of the Western Tradition , Vol 1*, (Boston, MA: Houghton Mifflin Company, 1991), p. 280.

CHART ACTIVITY

MUSLIM SCIENTISTS ON EUROPE'S BOOKSHELVES 15TH CENTURY AND BEYOND

Background for the Teacher

Like detectives, historians interested in knowing such things as how technology and other ideas influenced the West, try to piece together evidence. For example, a historian might learn that an invention was used in Muslim lands before it was used in Europe. They try to trace when and by what route the invention was passed on. The mathematician Leonardo of Pisa, known as Fibonacci, is thought to have been responsible for transferring Arabic numerals to the West from Muslim culture. He is known to have been exposed to this knowledge through his studies in North Africa. The fact that Roger Bacon was familiar with Muslim scientific work is proven by his translation of the famous book *Secretum Secretorum* ("Secret of Secrets"), and by his many citations of Arabic authors. Another historian has discovered a document stating that Copernicus was given a book that contained Jabir Ibn Aflah's work *Treatise on the Reform of the Almagest*—a critique of Ptolemy's system. Copernicus was the Western astronomer who began to refute the writings of Ptolemy in favor of a sun-centered solar system.

A very broad source of evidence that Muslim science influenced the Scientific Revolution is found in the careful work of cataloguing rare books, the first ones printed in Europe after Gutenberg. The bibliographical scholar Margaret Stilwell compiled a catalogue of scientific books printed in Europe during the first century of printing, from the 1450s to the 1550s. We know, for example, that many works were translated from Arabic into Latin during the 12th century, in Spain. And we know that these books were transported into Europe and used by French, Italian, English and other scholars. Stilwell's work, however, lets us prove two things that are often incorrectly stated:

1. that the Arabic works that influenced European science were NOT simply translated Greek works. In addition to translation, the Arab scholars wrote commentaries and critiques on Greek studies, and expanded upon the knowledge they inherited from their ancient predecessors by writing original scientific works in many fields.
2. that Muslim influence on the sciences did NOT end in the medieval period during the 12th century, but it extended into the time of the Renaissance and the Scientific Revolution.

In fact, there were many important original Muslim scientific works printed, and reprinted over the next centuries. It is clearly possible, also, that the influence of Muslim science on European thinkers was MORE important after printing made the works available to many scientists all over Europe.

In scientists' libraries and book shops from England across the Channel and across the Alps to Italy, dozens of Arabic scientists' books were printed in Latin, with the Arabic authors' names changed to Latin equivalents, like Avicenna, Averroes, Serapion, and Geber. This list gives us solid evidence that knowledge developed centuries earlier by Arabic scholars was still in demand during the Scientific Revolution. The number of books and editions printed—in the hundreds and thousands—is evidence that these Arabic scientists must have been household names as the Renaissance flowered into the Scientific Revolution of the 16th and 17th centuries. The fact that these books were published at a time when printing was still expensive and painstaking, involving financial risk for the printer, is clear evidence of their importance. Finally, we can conclude from the continued printing, and even new translation of books from Arabic in the 17th century, that the transfer of knowledge

from Islamdom to the West did not end during the 12th century, as many textbooks and other sources state. The fields of intercultural and scientific history are still relatively new, and there is surely much more to learn. One specialist on Muslim science states that contemporary libraries around the world contain about 250,000 Arabic manuscripts, some of which have not yet been studied. Some of these may contain important clues about the history of science and technology.

STUDENT ACTIVITY

1. The teacher should read the above background material, but not reveal it to the students until the end of the activity. At that time, students may receive it as a handout, but not until they have completed the activity and questions.
2. Have students look over the chart and describe what it contains and how it is organized.
3. Working as a class or in smaller groups, have the students work with the chart to answer the questions that follow, taking notes as they go along. At the conclusion to the activity, the students will summarize their findings in a brief paragraph.
4. How many scientific fields are identified as the topics of books printed? List them.
5. What generalization can be made about the authors of the printed books listed?
6. What is the language of most of the book titles? Can you guess or figure out what some of the titles mean? Why is it possible to decipher some of the words in the titles?
7. Note the dates of the following items for several books: (1) the date of editions, (2) the author's birth or death dates, or "fl." for flourished) and (3) the translator's dates. How many years apart are the author, the translator and the printing of the book? Looking at several rows of data on the chart, and comparing these dates, what generalizations can you make about the spread of knowledge? What generalizations can you make about the time when these books became known to Europeans?
8. Can you make an educated guess on how many books might have been printed in one edition? How would you find more reliable information on the number of books per edition? Find out which books were printed in more than one edition, at more than one location. What books seem to have the most editions? Estimate how many books might have been printed altogether. How geographically widespread do you think sales of the book must have been? Who would have purchased them?
9. Knowing something about the early printing industry in Europe from this resource collection, your textbook or an encyclopedia, role play or describe what factors in the market would be required before a printer—one of the earliest examples of a capitalist—would decide to produce a certain book. (see the story "A Day in Aldus Manutius' Print Shop" in Segment 2 of this unit for some help.)
10. Using this information and similar lists for other fields of publishing, it would be possible to imagine what a well-read scientist of the 1500s and 1600s might have had on the bookshelves in his (not often her) study. Discuss and try to draw some reasonable conclusions on the probable influence of Muslim scientific contributions on European scientific knowledge during the 12th century, the first century of printing, and the Scientific Revolution. Summarize these conclusions in a short paragraph. Do your conclusions differ from your earlier impressions of Muslim influence?

SKILLS ACTIVITY

SNAPSHOT FROM HISTORY: A MUSLIM SCHOLAR OF 9TH-CENTURY BAGHDAD

SETTING: Baghdad, the month of Ramadan, 217 AH (after the *Hijrah*), or 832 CE

PERSON: A middle-aged Muslim scholar, or *Hakeem*

PLACE: The House of Wisdom in Baghdad (*Bayt al-Hikmah*), founded in 830 CE by Ma'mun, son of the legendary *Khalifah* Harun al-Rashid. Later, *Khalifah* Ma'mun, hoping to aid the cause of learning in the Abbasid state, greatly expanded the House of Wisdom, making it a museum, library, translation office, teaching institute and conference center. Scientific and other works were translated into Arabic from Greek, Persian, Syriac, Hebrew and other languages. He hired Persian, Christian, Jewish and Hindu scholars to work side-by-side with Arabic-speaking Muslims to translate books and write new works on many topics. The books were copied and illustrated by calligraphers and artists, and bound to be stored in the House of Wisdom's large library. Translators were sometimes rewarded in gold according to the weight of the books.

TEXT OF POSTER CAPTIONS

a) The *Hakeem* writes on a **low desk of wood**, inlaid with **ivory** and **ebony** from Africa, and **mother-of-pearl** from the Persian Gulf.

b) He writes a **letter** about his latest work to a fellow scholar in al-Andalus, or Muslim Spain, using a **reed pen** carefully cut and trimmed from plants grown on the banks of the Tigris River. The ink is made from **lamp-black** and **gum arabic**.

c) The writing is **Arabic script**, universal language of scholars across Muslim lands from Spain to Central Asia. Since Muslim scholars used **Arabic** as the language of learning, they had no trouble communicating ideas from place to place. This helped to advance learning in the Muslim lands, from which it later spread to other cultures.

d) He writes on **paper** made in Baghdad from cotton fiber. Paper is a new product for Baghdad; it originated in China, and was brought to Muslim lands after 750. It is rapidly replacing parchment and papyrus—in use since the time of the ancient Egyptians. Paper has begun to spread across the Middle East, North Africa, and Spain, but it will not arrive in Christian Europe until the 13th century, when it is brought by pilgrims and scholars traveling to Spain.

e) In the background are **shelves of books** in one of many **libraries** in Baghdad. Some libraries contain thousands of volumes, catalogued and placed flat on the shelves. Some libraries are even cooled by water flowing through pipes.

f) **Volumes stacked on the floor** represent some of the scholars's many works on medicine, philosophy, astronomy, mathematics and religious subjects. This *Hakeem*, like many others, has a broad education and is interested in many fields.

g) A **copy of the *Qur'an*** is placed, as a sign of the great respect given it by Muslims as holy scripture, on a **special stand of fragrant, carved sandalwood** imported from the tropical forests of Southeast Asia. The *Hakeem*, like any educated Muslim, began his schooling by memorizing the *Qur'an*. The *Qur'an* is also inspiration for the *Hakeem's* scientific work; it contains many references to seeking knowledge and investigating the creation. The *Qur'an* shows beautiful **calligraphy**, or decorative writing, and **illumination** in geometric designs, using inks with gold and jewel-like colors.

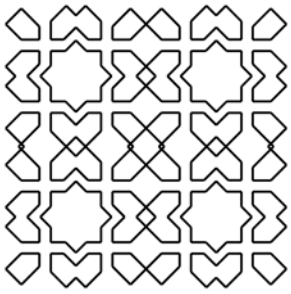
h) The *Hakeem*'s **turban** is wrapped from several yards of thinnest muslin cotton, named for the city of Mosul where it is manufactured.

i) His **robe** is made of **damask**, rich cloth with a floral pattern woven into it, a specialty of the city of Damascus, Syria. The robe was a **traditional gift of honor** from the *Khalifah* Ma'mun as a token of appreciation for the *Hakeem*'s scholarly achievement.

j) It is late afternoon, and the scholar's **stomach** is empty, and he is thirsty. **Ramadan** is the month of **fasting** for all Muslims, but at sundown he will break his fast, pray and enjoy dinner at the court or at one of the palaces of prominent Baghdad residents.

Student Activity

1. Cover all of the text and captions on the poster with sticky-notes. Ask groups of students to guess the time, geographic region and occupation of the person pictured. Have them list items shown that might provide clues to answer these questions.
2. When they have agreed on the identification of the person, place and time, uncover the text headed "Setting", "Person", and "Place." Ask students what features they used for clues. If they were near correct, they should indicate what led them to their conclusion.
3. With the remaining text still covered, students should list each item pictured on the poster and discuss its significance to the person and his status or occupation, and his personal values.
4. In the final stage of picture study, students should make informed guesses about the geographic origin, materials of which it is made, and historical or cultural significance of the items on the list. This activity can be used as a springboard for classroom research, having the students look up the items in reference works, or it can serve as a tool for reviewing material from this unit, as most of these items are covered.
5. Uncover the captions and discuss each with the whole class, with emphasis on their personal significance to the Abbasid scholars, the cultural and religious values they indicate (possibly with reference to relevant verses from the *Qur'an* or *hadith* found under a subject index), and their historical significance in terms of Muslim civilization and its influence on other civilizations.
6. Research the life and works of several Muslim scholars from the Abbasid period. (A few suggestions: al-Biruni, al-Razi, Ibn Sina, al-Jahiz, Hunayn, al-Jazari, Banu Musa bin Shakir, Abu al-Faraj al-Isfahani)



FEATURE ACTIVITY

THE *HAKEEM* AND THE "RENAISSANCE MAN"

BACKGROUND FOR TEACHER

THE HAKEEM • With the spread of Islam, a group of learned scholars, or *ulama,* developed, who pursued learning in various branches of knowledge. A number of individuals emerged whose accomplishments were similar in scope to the varied achievements of the Western "Renaissance man." Such a scholar was often called a *Hakeem*. The term *Hakeem* comes from the Arabic word *hikmah,* meaning "wisdom".

A *Hakeem* was a scholar of religion and philosophy, a writer, a teacher, a traveler, and a scientist. It was also assumed that the *Hakeem* would be trained as a physician and a judge, since the focus of higher education in Muslim culture was on medicine and law, based upon the necessary foundation of religious studies. The true *Hakeem* was expected to be a very well traveled individual. Although there are several reasons for this, there is one very obvious one; no matter where in the world they are born, Muslims are expected to make the ***Hajj*** or pilgrimage to Makkah if they are physically and financially able. (Although thousands of Christians made a pilgrimage to Jerusalem to visit their holy land, it is not a clearly stated religious *duty*. For Muslims, making the *Hajj* is one of the Five Pillars of Islam, and as such, its mandatory.) As early as the 8th century, Muslims were traveling all the way from Africa and Central Asia to the city of Makkah on the Arabian peninsula. Regular *Hajj* caravans left annually from major cities such as Baghdad, Damascus and Cairo. In the 15th century, the famous Chinese Muslim explorer, Cheng Ho, made his way to Makkah, crossing the ocean in a fleet of huge Chinese junks.

Qur'anic revelation also encourages all Muslims to gather knowledge. In addition, there are many *hadith* (sayings of the Prophet Muhammad) which indicate that seeking knowledge is a religious activity incumbent upon every Muslim. Many scholars set out upon a journey for the sake of acquiring knowledge, called in Muslim culture *rihlah fi talab al-ilm*. Travel was such a prominent feature of Muslim culture that a scholar like Ibn Battuta was able to begin his journey in Morocco and end up in China without ever leaving the Muslim cultural sphere called the *Dar al-Islam* ("abode of Islam"). Another representative example of a typical *Hakeem* is a scholar from Cordoba, Spain who left home at the age of 14, in the year 941. By the time he finished his studies, he had visited Makkah, Medina, Jidda, Yemen, Fustat, Jerusalem, Gaza, Ashkelon, Tiberias, Damascus Tripoli, Beirut, Caesaria, Ramla, Farama, Alexandria, and Qulzum.[56]

THE RENAISSANCE MAN • The term "Renaissance Man" has been used to describe men such as Leonardo da Vinci, and Michelangelo, two intellectual and artistic giants of the European Renaissance. What amazes us about them today is not just their genius in any one field, but the fact that they excelled in many skills and fields of knowledge. They were extremely prolific, producing many works of art and literature during their lifetimes. It makes us wonder today if time didn't somehow move more slowly then, enabling these individuals to know so much and produce so much, in an age without cars, computers and communication devices. In this section, we will explore the careers of highly productive, famous "geniuses" from two cultures and two historical periods. Perhaps the study will be useful in discovering what such people have in common.

Both Leonardo and Michelangelo lived during the "High Renaissance" period of the 15th and 16th centuries. They personified the ideals of the epoch as scholars, artists, writers, inventors and scientists. Renaissance leaders were sought after to carry out commissions for wealthy patrons. They executed paintings, designed palaces and civic buildings and decorated them. These works reflected the generosity, but also the political power, importance and wealth of the person who commissioned the work. Much of Renaissance art glorified God by depicting religious scenes and figures. Sometimes the painter included the patron, or a symbol indicating which patron donated the work, in the composition. Old Testament stories covered walls and ceilings of

56. Sam I. Gellens, ***Muslim Travelers,*** **( ), pg. 55.**

government palaces, private residences of the wealthy, and cathedrals. Renaissance artists also created some of the greatest works of religious architecture in western history. Today Western culture has come to think of great artists of the past as geniuses and even heroes. During medieval and even into Renaissance times, artists were craftsmen running large shops or studios with apprentices who prepared pigments and did other tasks. Of course, lesser-known painters were apprenticed to the master to paint sections of less important commissioned works. The willingness of wealthy and aristocratic people to view the (often temperamental) artist as a genius and cultural hero owes no small part to the two extraordinary personalities and talents of Leonardo and Michelangelo. Through their work, they redefined what it was to be an artist, and raised their status to the level of aristocracy. Many Renaissance artists were well acquainted with nobility. For example, in his youth, Michelangelo was honored by an invitation to live with the powerful Medici family. Later in his life, he was so sought after that popes and royalty fought over who would employ him. A number of Renaissance artists actually became quite wealthy.

Intellectual leaders of the Renaissance also made great advances in science and technology. Many of the seeds of this great flowering of ideas were planted by the medieval scholars who lived within *Dar al-Islam* (the "Abode of Islam", or Muslim lands). Great centers of learning in cities such as Damascus, Baghdad, Alexandria and Timbuktu in Africa, Jundi-Shapur in Persia, and Cordoba and Sevilla, in Spain attracted scholars from all over the world. Here they benefited from the wisdom of learned scholars and libraries which contained thousands of texts. When Europeans translated, then disseminated these works into Europe, this knowledge became part of the European intellectual heritage. During the Renaissance, many of the works that had been translated centuries earlier were made available as printed editions. At this time, the impact of this learning rapidly increased. Many new European works that came into print reflected the process of absorbing the knowledge of Arab scholars, in fields such as agriculture, mathematics, metallurgy, and astronomy. The efforts of the humanist scholars who rediscovered Greek learning represented a different, and in many ways uniquely European movement, but their impulse grew out of the vast influx of knowledge, which included Arabic versions of many classical Greek works. Their revival of classical Greek and Roman literature paved the way for new content in the arts, which now included subjects from classical mythology. These rediscoverers of ancient wisdom fanned the flames of the Renaissance, encouraging the changes in scholarship that brought forth the ideals of the "Renaissance man."

True Renaissance thinkers questioned the reason for their existence and placed mankind within some sort of natural and religious order. They grappled with such questions as "Why was man placed on earth, and where does he stand among all of God's earthly creations?", "What happens to the soul after death?" and "What is man's relationship with God?". Eventually, in conjunction with the overall religious upheaval of the Reformation, conflict over the discoveries of scientists versus the doctrines of the Church arose within Europe. As the Renaissance progressed, European thinkers continued the medieval debate over reason and faith, as a number of thinkers immersed themselves in philosophy. Many of these men also referred to translations of works by the great *Hakeems*, such as Ibn Sina (Avicenna), al-Kindi, al-Farabi and others. This and other studies based on speculation as well as experiment and observation enabled them to develop methods of scientific experimentation that opened the path to the scientific revolution of the 17th century.

Student Activity

1. Read the following short biographies of two famous *Hakeems*, al-Razi and Ibn Rushd, and the two best known Renaissance Men, Leonardo da Vinci and Michelangelo. What made the Arab scholars such valued individuals, not only in Muslim lands, but in Europe as well? What made Leonardo da Vinci and Michelangelo so famous that they are still revered in the modern age?

2. Although there are many similarities among these four people, you will also discover some significant differences. What do their choices of life goals and the focus of their studies have in common, and how do they differ? These similarities and differences reflect the values of the two cultures.

3. Write a list of the values you see reflected in the lifetime achievements of these men, and then discuss how they are similar and how they are different. What do you think are the roots of these similarities and differences?

THE HAKEEM

al-Razi

Al-Razi (865-925 CE)

Admired in both Western and Muslim societies, Abu Bakr Muhammad bin Zakariya *al-Razi* (known as "Rhazes" in Latin) has been called "the unchallenged chief physician of the Muslims" and "the most brilliant genius of the Middle Ages." Manuscripts have been discovered in which al-Razi wrote about philosophy, logic, astronomy, math, physics, medicine and music. (He played the *ud*, which is a forerunner of the guitar). With this wide array of interests and skills, al-Razi exemplifies what Europeans always admired in a true "Renaissance Man".

At an early age, al-Razi developed an interest in the healing arts. A Persian by birth, he traveled in his youth to the vibrant city of Baghdad, which in the 9th and 10th centuries, was one of the world's greatest centers of scholarship and medical studies. By the time he returned to Persia, al-Razi's reputation as a scholar, lecturer and physician enabled him to become the director of a hospital near Tehran. He also served as physician to the rulers of Persia.

Al-Razi's gentle and generous nature, as well as his teaching skills, attracted students from across the Muslim lands, who traveled to Persia just to study under this brilliant physician, mathematician and philosopher. Like the ancient Greek physician Hippocrates, al-Razi urged physicians to enter formal training, to be licensed, to be cautious of charlatans in the health field, and to dress, eat and live simply. He also observed the connections between eating a balanced diet, reducing psychological stress, and maintaining one's health. One book of essays he wrote, called *Spiritual Healing*, discusses the importance of avoiding anger and conflict, of moderation in food and drink, and other healthful practices.[57]

A prolific writer, this many-sided scholar studied the medical writings of Hippocrates and Galen (another ancient Greek philosopher and physician), and corrected mistakes which both of them had made. Al-Razi collected medical data, performed experiments, and, while in Baghdad, wrote his book *al-Tibb al-Mansuri*. His text was later translated into Latin as the *Medicinalis Almansoris*. This book served as one of the most influential medical textbooks in the West throughout the Middle Ages. Later in his life, as he was approaching death and blindness, al-Razi wrote a medical encyclopedia which was so huge that there were only two copies made until a Jewish physician, Faraj bin Salim copied it in 1279 under the title *Continens.* This became one of the first medical books to be printed in the West (in 1486), and was reprinted many times over the next two centuries. It served as a university medical text in Europe during the Renaissance and beyond. Today, one can see al-Razi depicted in a beautiful stained glass window of the University Chapel at Princeton University, recognizing his broad contributions to science and scholarship.

57. You can sample al-Razi's essays in *Beyond A Thousand and One Nights: A Sampler of Literature from Muslim Civilization*, (Council on Islamic Education, 1999).

THE HAKEEM

Ibn Rushd

IBN RUSHD (1126-1198 CE)

"I believe the soul is immortal, but I cannot prove it," declared the frustrated philosopher, scholar, judge and physician, Abu al-Walid Muhammad ibn Rushd (known as "Averroes" in the West). Along with Ibn Sina ("Avicenna"), Ibn Rushd was instrumental in reintroducing Greek learning to Europe. For this reason, both of these scholars are considered major catalysts for the avid study of philosophy and religion which shook the foundations of European thought during the Renaissance. The works of Greek writers such as Aristotle and Ptolemy were translated into Arabic and expounded upon by the great Muslim *Hakeems*, or learned men. Their works were eventually translated into Latin, providing the vital link between the ancient Greek philosophies and the European Renaissance.

Ibn Rushd was born in Cordoba, Spain in 1126, a time when much of Spain was ruled by Muslims. It was under Muslim rule that Jewish, Christian and Muslim scholars from all over the world were gathered together to work on reclaiming and expanding upon ancient Greek philosophy. Muslim Spain was such a well-respected center of scholarship that the prominent families of Europe who wanted to increase their status sent their sons to Spain. There they could learn Arabic—an important language of scholarship and literature—and acquire a university education under the tutelage of Muslim scholars.

Ibn Rushd was born into a long line of distinguished scholars and judges. He followed the Muslim tradition of focusing his studies on religion, medicine and law. He never desired wealth or power, seeking only to increase his knowledge. According to one of his biographers, there were only two days upon which he did not study—the day of his wedding and the day his father died.

He led a quiet, contemplative life until, one day, a friend sent for Ibn Rushd to travel to Marrakesh to meet the Almohad ruler. Even though he was a well-respected scholar, an interview with such a powerful leader made Ibn Rushd quite nervous. When the ruler began to question him, he became apprehensive; philosophy and theology were potentially dangerous occupations. What if he offended the ruler? When Ibn Rushd insisted that he knew nothing of philosophy, the ruler recognized the discomfort of his guest, and told him the real reason for the interview. The ruler wanted Ibn Rushd to conduct an extremely important project—to continue analyzing the writings of Aristotle, and present commentary on Aristotle in a manner which would blend Greek and Islamic philosophy. He also appointed Ibn Rushd as religious judge of Sevilla and personal physician to the ruler's court. Ibn Rushd accomplished the task at hand with such energy and enthusiasm that he not only influenced the great Muslim thinkers of his time, but also set the foundations for philosophical discourse of the European Renaissance.

Ibn Rushd's most significant impact on Renaissance thought was the idea that there is no conflict between scientific study and religious belief; that someone could pursue scientific observation and experimentation and still be a devout believer in divine revelation. His most important work was a response to disputes among Muslim scholars over the validity of philosophy in the search for knowledge. Ibn Rushd recognized the value in such thought. With its translation the following century, his work became more famous in Western Europe than in his own culture, were it became better known much later. It was through the works of Ibn Rushd that Aristotle was introduced to the early humanists and scholastics. "Averroism", as his philosophy was called, became a hotly debated issue in European intellectual circles. The works of Ibn Rushd were studied by such great thinkers as St. Thomas Aquinas, St. Bonaventura and Roger Bacon. Ibn Rushd was so influential on Renaissance thought that by the 13th century, the Age of Scholasticism, the whole intellectual scene of Europe was dominated by debates over the writings of Ibn Rushd and other Arabic scholars who had expanded upon the ancient wisdom of the Greeks. It has even been said that with the commentaries of Ibn Rushd, which were translated from Arabic into Latin, two Aristotles entered the European mind: Aristotle's own work, and Ibn Rushd's interpretations of these works. By Dante's time (1265-1321), it has been said that "Averroes" was so famous that even the slightest *allusion*, or reference, to him in literature or art would be understood. Ibn Rushd's contribution was honored by including his portrait in several important Medieval and Renaissance paintings, including the fresco *Triumph of St. Thomas* and Raphael's *School of Athens*. (See slide study, Segment 4, pp. 280).

THE RENAISSANCE MAN

Leonardo daVinci

LEONARDO DA VINCI (1452-1519 CE)

The term "Renaissance Man" was coined to describe this genius who was born in 1452 on his father's estate in Vinci, Italy. At the age of 15, Leonardo's father apprenticed him to the artist Andrea del Verrocchio where he studied painting, sculpture and the mechanical arts. With his elegant clothes and his perfumed, curled beard, da Vinci developed a reputation as a vain eccentric. This reputation was further advanced by his habit of writing in an almost illegible script from right to left, using his left hand. He was a man of extreme contrast. He was an accomplished fencer and horse lover, as well as a vegetarian who refused to kill animals. He liked to purchase caged birds simply to set them free. Yet he produced hundreds of drawings which expressed a deep interest in warfare and a desire to invent mechanical devices—such as the first machine gun—that would kill humans more efficiently. For much of his life, the design of weapons and machines took him away from his artistic endeavors.

Leonardo was first employed by the Duke of Milan as his artist and engineer in residence. He worked as painter, sculptor, architect, and designer of fortifications, weaponry and hydraulic equipment. He developed sketch books which contained drawings of inventions. One such book, the *Codice Atlantico*, contained 17,000 drawings, many of which depicted primitive machinery which were to become modern inventions centuries after da Vinci's death. An imaginative man, Leonardo spent half his life struggling with his desire to enable humans to fly. He designed an early parachute as well as an elaborate set of mechanical wings for man. He also presented the city of Milan with a plan to turn it into a two-level city, with markets on the lower level and quiet walkways on the top, connected by spiral stairways.

Another of Leonardo's interests was human anatomy, a subject which he treated as both a science and as an artistic interest. As a sculptor and painter, his thorough understanding of the human body was reflected in the meticulous detail of skeletal structure, muscles and the mechanics of movement. His notebook sketches of human anatomical studies were so detailed that they laid the foundation for the modern science of medical illustration.

In his 17 years in Milan, he completed six paintings, one of them his "Last Supper." That famous and poignant painting depicted Christ eating dinner with his 12 disciples, one of whom would soon betray him to the Roman authorities.

The rest of Leonardo's life was spent between the city-states of Milan and Florence, where he completed his famous portrait of "Mona Lisa". Toward the end of his life he felt frustrated by the commissions he received in Italy, so he accepted an invitation to work in the court of the French King, Francis I. He died in Cloux, France and was buried there. The church and graveyard in which Leonardo was buried were destroyed during the French Revolution of 1789. His remains disappeared at that time and have never been found.

THE RENAISSANCE MAN

Michelangelo

MICHELANGELO (1475-1564 CE)

Michelangelo was born in 1475 in a small village near the city-state of Florence. He showed an interest in art at an early age, so his father, with some reluctance, apprenticed his 13-year-old son to the Ghirlandajo brothers, well-known Florentine artists. Michelangelo would often sneak out of his art classes to visit the gardens of the Monastery of San Marco. These gardens had many pieces of ancient Greek and Roman sculpture placed throughout. The sculptures were brought to the gardens by Lorenzo de Medici (Lorenzo the Magnificent). Lorenzo, ruler of Florence, was one of Europe's most powerful political leaders of the time. One day Lorenzo saw the young Michelangelo carving a faun's head from a piece of marble. He was so taken by the piece that he invited Michelangelo to live and study in the magnificent palace of the Medici family. From that point on, Michelangelo was treated like a son by Lorenzo.

Michelangelo spent his life between the two cities of Florence and Rome. When the Medici family fell from political prominence, Michelangelo fled to Rome. Shortly after his 1496 arrival, he was commissioned to carve a pieta, a marble statue of the Virgin Mary holding the dead Christ on her knees. This emotionally powerful masterpiece launched Michelangelo to fame and led to other commissions. One such job challenged him to carve a statue from a rare 18-foot high piece of marble that a less experienced sculptor had all but ruined. Working around the other artist's mistakes, Michelangelo created his well-known statue of David, the youthful slayer of Goliath. Like Leonardo da Vinci, Michelangelo worked in other fields besides art. When Florence was threatened with attack, the fortifications he designed were instrumental in the defense of the city. He was also an accomplished poet as well as an architect. His design for the dome of St. Peter's Basilica in Rome is considered not only a fine artistic achievement, but an important technical accomplishment as well.

One of the things that most frustrated Michelangelo's employers was his inability to finish things. He was often hired to design and build large tombs for powerful political figures or popes. Few of these were completed—sometimes because of political upheaval which forced the artist to flee for safety, and sometimes due to Michelangelo's moody nature. (His famous "flat" nose was the result of a fight he got into as a youth.). He had few friends, particularly among women, whom he considered a nuisance for most of his life. When a priest expressed regret that Michelangelo had never married, the artist replied that "I have only too much of a wife in my art, and she has given me trouble enough."[58] In contrast to Leonardo da Vinci's use of perfume and elegant clothing, this artist was often unbathed and dressed in filthy clothing. At times his artistic fervor over a project would become so consuming that Michelangelo didn't want to waste precious time taking his clothes off at night, so he would sleep in them, boots and all!

In spite of his difficult personality, patrons of art showered this artist with money and praise. One of his most significant commissions was to paint the ceiling of the Sistine Chapel. Pope Julius II requested a reluctant Michelangelo to take on this challenge. The ceiling was 68 feet above the floor. Lighting was poor, and there were 5,800 square feet of wall and ceiling to be covered with art. The project took four years (1508-1512) and upon completion, there were 343 figures painted on the ceiling. By the time this enormous undertaking was finished Michelangelo was partially blind, physically and emotionally exhausted and emaciated due to all the times the artist simply forgot to eat due to his focus on the work.

These ceiling frescoes depict the story of Genesis from the creation of Adam to the Flood. These paintings are undoubtedly some of the most famous works in the history of Western art. The paintings depict religious scenes with the typical confidence and vigor which characterized Renaissance art and typify the genius of artists such as Michelangelo.

58. Will Durant, *The Renaissance, A History of Civilization in Italy from 1304-1576 A.D.* ( ), p. 500.

FEATURE ACTIVITY

RETHINKING THE RENAISSANCE: MICHELANGELO'S PAINTING OF THE SISTINE CHAPEL

One of the great giants of the Renaissance was the painter and sculptor, Michelangelo. Most people are familiar with the work of this man, and his works continue to be admired even today. It is interesting, however, to look at how this artist's attitude toward the Renaissance "world view" changed as time passed. As a young man, Michelangelo was a confident artist who was sought after by Popes and royalty to do commemorative works in their honor. By the end of his life, he was weak, often ill, and, in the opinion of some historians, mad.

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The Sistine Chapel was first built in 1473 for the Renaissance Pope Sixtus IV, after whom it is named. It became the chapel for the popes at the Vatican in Rome. Before Michelangelo painted the ceiling, the walls were painted by other artistic giants of the Renaissance such as Botticelli, Signorelli and Ghirlandaio. This may be one of the reasons why Michelangelo was so reluctant to take on the job of painting the ceiling. It would be difficult to know that your work will be compared to the work of these other masters, and Michelangelo did *not* see himself as a painter; he felt much more at home with the art of sculpture, and wanted to have nothing to do with this chapel ceiling. It was Pope Julius II who offered the commission to the reluctant artist. Michelangelo had accepted jobs from him before and the two strong-willed men often quarreled about designs, fees and deadlines. This time when the commission was offered, the artist chose to flee Rome for Florence and ignore the letters from the Pope. This continued for two years until the Pope became furious, prompting the government of Florence to write a letter to Michelangelo demanding that he accept the job. In the letter they stated "We do not want to go to war with Pope Julius because of you."[59] After he accepted the job, the Pope continued to harass Michelangelo. Perhaps afraid that he wouldn't live to see the completion of this project, the elderly pontiff occasionally climbed up the scaffold and beat his painter with a stick in order to stress that the work had to be done quickly. The Pope died only four months after the ceiling was unveiled.[60]

Much of Michelangelo's later life was spent painting the ceiling and the altar wall of the Sistine Chapel. More than any other work of art, the paintings in this chapel represent the vastness of Renaissance philosophy and religious faith. The ceiling, painted between 1508 and 1512 is a masterpiece of High Renaissance art, reflecting Europe's confidence in the glories of mankind. The wall behind the altar, however, was painted when Michelangelo was much older. It reflects the fearful questioning of Renaissance Humanism that wove its way into the Italian psyche as the Roman Catholic church was dealt one blow after another of devastating wars, corruption, and calls for reform.

59. Henry R. Luce ed., *The World's Great Religions*, (New York: Time Inc. , 1957), p. 209.
60. Durant, Will. *The Renaissance*,(New York: Simon and Schuster, 1953), p. 476.

Even after Michelangelo agreed to paint the ceiling of the Sistine Chapel in the Vatican, the artist continued to protest that he was not the right person for the job. He feared that he would fail at the task of completing this difficult assignment. The ceiling was 68 feet high. There were 5800 square feet to be covered with fresco paintings, and Michelangelo knew he was poorly trained in the use of fresco (painting over nearly dried plaster so the paint enters into the plaster.) The artist was aging, weakening in health, losing his eyesight and feeling bitter, because now that he had to paint the ceiling, he would be unable to complete his work on Pope Julius' sculptured tomb. When he reluctantly accepted the commission, he had no idea that this piece would be considered one of the greatest masterpieces of the Renaissance.

The Pope wanted the ceiling to be covered with paintings of the Apostles. Michelangelo had a different idea and he was not going to allow the Pope to ruin this piece of art. Instead of the Apostles, the ceiling depicts the story of Genesis from the creation of the world to the fall and redemption of mankind. Michelangelo's work, both in sculpture and in painting, presented a mixture of classical Greek style infused with his own artistic creativity. He was a stubborn man who refused to follow the rules of convention followed faithfully by other famous Renaissance painters such as Leo da Vinci and Raphael. These men applied strict rules of mathematics to their work in an effort to guarantee perfect harmony and proportion. Turning his back on precision and mathematics, Michelangelo left measurements and proportions up to his eyes and heart alone. The theme and object used in these paintings is the human body. While using the sculpture of antiquity as inspiration, he rejected the classical use of the calm, idealized figure in peaceful repose. Instead, some of the figures he created seemed to burst with energy. Many are filled with passion and emotion, often expressed through the use of nudes depicted with taut muscles and facial expressions that cover a range from joy to fear to anguish.

More than 340 figures fill the ceiling with depictions of God's separation of light from dark and His creation of the world, the creation of man and woman, the temptation and expulsion from the Garden of Eden, the great flood, Noah's sacrifice of a lamb and the story of Noah's drunkenness, among other scenes taken from the Bible.

Along the sides are some of the prophets of the Old Testament as well as depictions of *sibyls*, or prophetesses who foretold the coming of Christ. These figures are surrounded by hundreds of youths and angels who interact with the Biblical figures. These statuesque nudes recall the pagan style of Greco-Roman art, which strongly influenced Renaissance artists and writers.

The Sistine paintings are undoubtedly some of the most famous works in the history of western art. They depict religious scenes with the typical confidence and vigor which characterized the Renaissance. The most famous of all the Sistine ceiling paintings is the one depicting the Creation of Man.

In his youth, Michelangelo was strongly influenced by the humanists. During his lifetime, Italy was equally influenced by thinkers such as Giovanni Pico della Mirandola (1463-1494), a writer and philosopher who had mastered Greek, Latin, Hebrew and Arabic. His most famous work, *Oration on the Dignity of Man*, is viewed by many as heralding the Humanist attitude concerning man's relationship with the world around him and with God. (*see Document #1 on page 248 for excerpts of this work*). In this essay, Mirandola places man higher than the angels. The author even claims to literally quote God in his writings, as if he were present when God created mankind! Mirandola describes how God told man that he [man] has the power to be and do what ever he wants. Like the gods of ancient times, Man is even referred to as being "neither mortal nor immortal". This attitude implies, of course, that God has little power over the fate of humans, and that our destiny is determined by us, and only us. This idea that people have the power to shape their own destiny became one of the key elements of modern thought.

The influence of humanism is most clearly depicted in this central scene, where the viewer looks up to see God reaching out to touch the finger of Adam. In that electrifying moment, life is passed from the Deity to the creation. Instead of using a more humble, traditionalist approach, the story is depicted from the Humanist point of view because that's what Michelangelo was most comfortable with at this time in his life. Man is being glorified here as the most magnificent creation of God. Even though Adam is seen in the earthly realm and God transcends above him, Michelangelo painted the Creator and the created equal in size! (This brought fearful criticism from some viewers.) Both God and Adam are depicted as superhuman in stature and grandeur.

Peeking around God's shoulder is a female who looks on in meek wonder. Most scholars believe her to be Eve before she is created. (Her creation is depicted in the next scene.) This painting refers back to pagan art and literature which depicted the gods as interacting with humans and even having human traits such as jealousy or anger. These scenes demonstrate the Renaissance union of pagan belief with Christian tradition.

Even though Michelangelo was uncomfortable with the medium of fresco due to his lack of training, he painted this scene with such confidence and emotional fury that it was completed in three days (with almost no sleep) and needed no touch ups! This sort of perfection was practically unheard of—other parts of the ceiling had to be re-worked for *months* before they were considered good enough to be viewed by the Pope.

The Altar Wall

More than twenty years had passed between Michelangelo's painting of the Sistine Ceiling and the massive wall behind the altar of the chapel. By this time, Renaissance Italy had experienced a radical change of mood. The influential Medici family who had supported so much of Michelangelo's work had fallen from power. When the Medicis managed to regain their rule of Florence, they did so as tyrants. Popes were grasping for power and wealth, bringing an unprecedented level of corruption to the Church. Italy had been laid waste by French and Spanish invasions. Calls for reform of the Church were being sounded throughout the land. Humanism began to recede as a resurgence of religious faith accompanied by pessimism gripped many people.

While Humanist confidence concerning the relationship between God and man is brilliantly reflected in Michelangelo's ceiling depiction of the Creation of Man, Michelangelo had been overcome by a pessimism bordering on madness for much of his adult life. He had few friends and worked unsuccessfully with others—in fact he fired most of the assistants who tried to help with the Sistine ceiling. Though he earned enormous sums of money, he often lived in poverty while family members drained off his wages. His consuming passion for his art drove him to work until exhaustion overtook him, at which point he would crawl in bed, still wearing his clothes–boots and all. He thought it was absurd to undress when he knew he would simply have to dress again in the morning. He was known to be filthy and unkempt in a time when marvelous perfumes and elegant fabrics were so highly valued among the elite.

At the age of sixty, the frail and exhausted Michelangelo was again pressed into service by the Pope. This time it was Paul III who insisted that the genius create a depiction of the Last Judgment on the wall behind the altar of the Sistine Chapel. The intimidating scene was painted on a massive surface that was 66 feet high and 33 feet wide.[61] This wall was the most important in all of western Christianity. Here, in view of the awesome scene depicted in this painting, generations of future popes would read the Mass.

Perhaps Pope Paul III didn't realize how tormented Michelangelo had become by this stage of his life. The artist's life had become darkened with thoughts of damnation and the misery of hell fire. This so obsessed him that in his old age he became convinced that some of his former paintings should be considered a sin.[62] Michelangelo was a great admirer of the writer Dante whose *Divine Comedy* is considered a Renaissance masterpiece. Dante's story depicts a journey through heaven and hell and warns of the torment that awaits those who sinned in body and mind out of arrogance. Another strong influence on Michelangelo was the Dominican preacher Girolamo Savonarola. His fiery sermons brought prophecies of doom and denounced human wickedness, tyranny, corruption in the Church, paganism and the arrogance of Renaissance philosophy. Tormented by these warnings, Michelangelo set his brush to the wall of the chapel to depict the final blast of the trumpet on Judgment Day. When the Pope (who had fathered 4 illegitimate sons before entering the priesthood) first viewed the finished masterpiece he fell on his knees and prayed "Lord, charge me not with my sins when Thou shalt come on the Day of Judgment."[63]

61. Durant, p. 715.

62. Durant, p. 501.

63. Luce, ed., p. 209.

Again, Michelangelo used the human body as the instrument of his art, but this time the range of emotions is so broad that it would be hard to find an emotion which is not depicted on this wall. In the center of the work, he shows Christ as angry and unforgiving. With one sweep of his arm, he sends to damnation all those who, in their arrogance, failed to follow God's commandments.

At the bottom of the painting are scenes from Hell. A fiery-eyed demon—straight out of Dante's *Inferno*—leads a boat full of the damned to meet Minos, the Gatekeeper of Hell. Michelangelo chose to inject a bit of sarcastic humor into this scene. Biagio de Cesena was the Master of Ceremonies for Pope Paul III. He had seen this painting before its formal unveiling and immediately complained to the Pope that Michelangelo was using too many nudes. Biagio claimed that such a glorification of the human body was better suited for a wine shop than the chapel of the popes. When the painter heard of this insult he painted Biagio's face onto Minos, the Gatekeeper of Hell, as an appropriate place for a Master of Ceremonies! This was a very serious matter at that time. Being depicted in Hell for all to view for eternity was a terrifying situation. Biagio immediately insisted that the Pope force Michelangelo to take him out of the painting, upon which the amused Pope replied "Not even a Pope can release a soul from Hell."[64]

At the feet of the depiction of Christ sits Saint Bartholomew, the Christian martyr who was skinned alive. One hand holds the knife that was used by his persecutors. In the other is his skin topped by a grotesque drooping face which is actually a self-portrait of Michelangelo. Other saints are also depicted in this painting. Saint Catherine holds part of the spiked wheel on which she died and Saint Sebastian holds the arrows that pierced his body. Hiding behind the depiction of Christ is Mary, the only fully draped figure. She looks on in terror and sorrow at the scene around her. This painting is a dramatic depiction of the agony and fear that tormented Michelangelo at the end of his life. Not only his painting, but his poetry as well expressed his fear that perhaps the Renaissance had "gone too far." In the following poem, he turns to Christ on the cross and seeks forgiveness for the artistic arrogance that he had participated in as one of the great giants of the Renaissance.

Now that my life across a stormy sea,
Like a frail bark, reached that wide port where all
Are bidden, ere the final judgment fall,
Of good and evil deeds to pay the fee.

Now know I well how that fond fantasy,
Which made my soul the worshipper and thrall
Of earthly art, is vain…

[Neither] Painting nor sculpture now can lull to rest
My soul, that turns to His great love on high,
Whose arms to clasp us on the cross are spread.[65]

64. Durant, p. 716.

65. Durant, p. 717.

Document 1

EXCERPTS FROM PICO DELLA MIRANDOLA'S *ORATION ON THE DIGNITY OF MAN*

In this document, Pico claims that human beings are not assigned a fixed place in the universe. Humans are told, through Pico's presuming to quote God, that they are in complete charge of their destinies, and that they can even hope to attain immortality (the ability to live forever), just like the ancient gods of the Greeks.

Some people see this document as the declaration of Humanist philosophy and note its strong influence on modern thought. Some also see this document as signaling the beginning of the fall of religious faith in the West.

After listing various philosophers, including ancient Egyptians, Greeks and an Arab, who offered opinions on why man is the greatest of God's creations, Pico goes on to state that their comments are helpful to him, but they somehow miss the point. After that, Pico offers his own opinions of why "man is the most fortunate of creatures and consequently worthy of all admiration":

> *"God the Father, the supreme Architect, had already built this cosmic home we behold…by the laws of His mysterious wisdom. Therefore when everything was done He finally took thought concerning the creation of man.…He therefore took man as a creature of indeterminate nature and, assigning him a place in the middle of the world, addressed him thus:*
>
> > 'Neither a fixed abode nor a form that is thine alone nor any function peculiar to thyself have we given thee, Adam, to the end that according to thy longing and according to thy judgment thou mayst have and possess what abode, what form, and what functions thou thyself shalt desire. The nature of all other beings is limited and constrained within the bounds of laws prescribed by Us. Thou, constrained by no limits, in accordance with thine own free well, in whose had We have placed thee, shalt ordain for thyself the limits of thy nature. We have set thee at the world's center that thou mayst from thence more easily observe whatever is in the world. We have made thee neither of heaven nor of earth, neither mortal nor immortal, so that with freedom of choice and with honor, as though the maker and molder of thyself, thou mayest fashion thyself in whatever shape thou shalt prefer.'
>
> *O supreme generosity of God the Father, O highest and most marvelous felicity [joy] of man! To him it is granted to have whatever he chooses, to be whatever he wills."* [66]

66. Perry, Peden, von Laue. ***Sources of the Western Tradition, Second Edition***, (Boston, MA: Houghton Mifflin Company, 1991), pp. 12 -13.

Discussion Questions and Suggested Activities

Document 1: Excerpts from Pico della Mirandola's *Oration on the Dignity of Man*

1. According to Pico, what powers has God given to man ?
2. How does Pico claim to know this?
3. What values are being glorified in this document?
4. Do we still value those things today?
5. Do you think all cultures share these values? If not, how do you think some cultures may differ in what they value?

Student Activity: Role Playing

- As you know, many Renaissance paintings depicted religious themes, expressing the artist's devout piety and love for their Christian faith. Toward the end of the Renaissance however, some paintings offended their viewers for what was considered a diminishing respect for divine events or actions. For instance, Dominico Ghirlandaio, a 15th century Italian painter, was commissioned by the wealthy Tornabouni family to paint a religious mural on the walls of the Santa Maria Novella choir in Florence. The subject was to be scenes from the lives of St. John the Baptist and the Virgin Mary. The most famous of these paintings is the one of the Birth of the Virgin Mary. Ghirlandaio, with happy support from his sponsors, chose to depict Mary being born in the rich interior of a Renaissance palace owned by the Florentine Tornabuoni family. To honor his employers, the artist portrayed the birth of the Virgin in a scene which places more emphasis on the status and wealth of this family than on the religious theme it is supposed to be depicting! The central figure in the painting is not St. Anne (the mother of Mary), who is far off to the right, nor is it the infant Mary. It is a young Tornabouni woman who, in her elegant stance and rich fabrics, steals the attention away from the sacred scene, which has been relegated to a corner of the work. With painstaking detail, Ghirlandaio shows the details of the woman's clothing, her hair, her delicate hands, and the Greco-Roman statues that fill her home.

  By the end of the Renaissance, some people, including Michelangelo, were questioning whether or not the Renaissance had encouraged too much arrogance in Europe. Paintings such as these created apprehension in those pious, God-fearing Christians who saw humility as an integral part of their religious devotion.

Student Activity: Role Playing

- Role play a panel debate concerning the glories of Renaissance art, using the Sistine Chapel ceiling, the Sistine Chapel altar wall and Ghirlandaio's *The Birth of the Virgin Mary*. Begin by researching the lives of the people on the panel and then argue what you think *their* point of view would have been. (Be careful not to interject your own opinion into the debate.)

The debate should focus on two different points of view. One group would include Pico della Mirandola, Dominico Ghirlandaio, Michelangelo at a **young** age, and one of the powerful Tornabouni women who were patrons of the arts. This group will argue that Renaissance artists were perfectly justified in portraying sacred scenes within a humanist context. The other group should include Michelangelo at a later age, the Dominican monk Girolamo Savonarola, the writer Dante, and Pope Paul III. This group will argue that Biblical stories are too sacred to be portrayed within a humanist light and that the world of the Divine should only be depicted with reverence and caution, portraying Man in a less glorified manner.

EXPLORING VALUES ACROSS CULTURES AND IN OUR TIME

SEGMENT 3: SCIENCE AND TECHNOLOGY

What are values? The dictionary defines ***values*** as "principles, standards, or qualities considered worthwhile or desirable". Use the list below and fill in additional values discussed in Segment 3 of this unit. Investigate the cultural values discussed in this segment from the following points of view:

- How were these values expressed in European Renaissance society? What events, cultural products and personal stories (biographies) are related to these values? What is the relationship between these values and religious beliefs and ideas in Renaissance Europe?
- How were these values expressed in Muslim society? What events, cultural products and personal stories (biographies) are related to these values? What is the relationship between these values and religious beliefs and ideas in Muslim culture?
- Do these values find expression in 20th-century society? If so, what recent events, cultural products and personal stories (biographies) are related to these values? What is the relationship between these values and religious beliefs and ideas in modern life?

List some of the cultural values discussed in Segment 3. Here's a list to help get you started:

1. Respect for the learning of other cultures
2. Respect for religious guidelines in scientific work
3. The importance of individual initiative in discovering and applying new techniques, great personalities in the service of human civilization
4. Scientific study as an expression of religious belief and spirituality
5. Science and technological advancement as an expression of worldly power and patriotism
6. Careful critique, observation and experiment in discovery of new knowledge
7. Preserving and transmitting knowledge
8. The belief that learning increases faith

■ Identify other values discussed in the segment and write them below.

9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____

ADDITIONAL SUGGESTIONS FOR STUDENT ACTIVITIES

1. Research the technology behind a traditional craft process from any historical culture. Prepare a short report on the technical requirements and possibilities in producing the articles. If possible, find one or more illustrations.
2. Visit a museum to see first-hand examples of Muslim crafts in glassware, ceramics, metallurgy, calligraphy or other fields. Most museums can arrange special visits to the vaults and display rooms by interested scholars, or teachers and students. There you can see pieces close-up, and the curator will provide special information and answer questions. While the group is at the museum, allow time to look carefully at the crafts of other cultures on display, and try to imagine what materials and skills were required to make them.
3. Visit a planetarium or plan a session looking at the stars with a telescope. View a video on the wonders of deep space based on images gained since the Hubble Telescope was deployed. Contact NASA or various astronomy web sites on the Internet to discover the exciting state of astronomy today.
4. Make a star map of one constellation, and find out information about the distance from earth of major stars, their importance for navigation, and when it appears in the sky, etc. Research the "literary" story of the constellation. What picture did people see in this group of stars, and what meanings did they give it?
5. Read *The Man Who Counted* and try to solve some of the mathematical riddles. What was the significance of mathematical studies in medieval times? Investigate the role mathematics and number theory (and "magic" properties) has played in various historical cultures.
6. The history of petroleum use does not begin with the 20th century. Research ancient uses for petroleum and trace developments to its modern "discovery" and exploitation? Are current uses similar to earlier ones? What parallels and contrasts exist?
7. Plague extension activities: (a) Research the cause of the Black Death and its origin. What effects did it have on the Far East and Central Asia? Is it known to have reached Africa? What routes did it take? (b) Read selected tales from the medieval series by Boccacio called the *Decameron*. What is the occasion for the storytellers' gathering? (c) Using the lists of effects of the plague in Europe and the Muslim Middle East, find specific historical illustrations for a few of the generalizations given as "results" of the plague.
8. **Medicine and Language:** Have the students research the word history and meaning of descriptive terms for personality and mood such as "phlegmatic," "humorous," "bilious," "sanguine," and "splenetic."
9. Choose one important invention from the medieval or Renaissance period from the following and research two or three historians' views regarding its origins and development: SPINNING WHEEL, WATER WHEEL, WINDMILL, STAINED GLASS, GUNPOWDER AND CANNON, COMPASS, LATEEN SAIL How much agreement is there among the historians, and how certain does the evidence seem to be? What evidence for its origins and spread is presented?